Electronic Services - Los Angeles
M12801X

OPERATING INSTRUCTIONS

TYPE 1153-A,-AP

DIGITAL FREQUENCY METERS

GENERAL ELECTRIC
INSTRUMENTATION & COMMUNICATIONS
1200 KONA DRIVE
COMPTON, CA 90220
(213) 642-5317

TYPE 1153-A

GENERAL RADIO COMPANY

OPERATING INSTRUCTIONS

TYPE 1153-A,-AP

DIGITAL FREQUENCY METERS

Form 1153-0100-A
November, 1965

Copyright 1965 by General Radio Company
West Concord, Massachusetts, USA

GENERAL RADIO COMPANY
WEST CONCORD, MASSACHUSETTS, USA

CONDENSED OPERATING INSTRUCTIONS

● CHECK

Set controls as follows:

Input controls
- TRIGGER LEVEL . . . centered
- INPUT COUPLING . . . AC
- IMPEDANCE . . . . . 100 kΩ

MEASUREMENT. . . . . 100 kc TEST
DISPLAY TIME . . . . . 6 or 7

COUNTING TIME . . . . . Display should read

.01	SEC	0.1000
0.1	SEC	100.00
1	SEC	00000, SPILL lamp on
10	SEC	00000, SPILL lamp on

● FREQUENCY MEASUREMENT

Set controls as follows:

Input controls . . . as required
MEASUREMENT . . FREQUENCY
DISPLAY TIME . . . as required

COUNTING TIME . . Right-Hand Indicator Reads

.01	SEC	hundreds of cycles per second
0.1	SEC	tens of cycles per second
1	SEC	cycles per second
10	SEC	tenths of cycles per second

● CUMULATIVE-COUNT MEASUREMENT

Set controls as follows:

Input controls . . . as required.
MEASUREMENT . . COUNT
DISPLAY TIME . . . any position, 0 through ∞

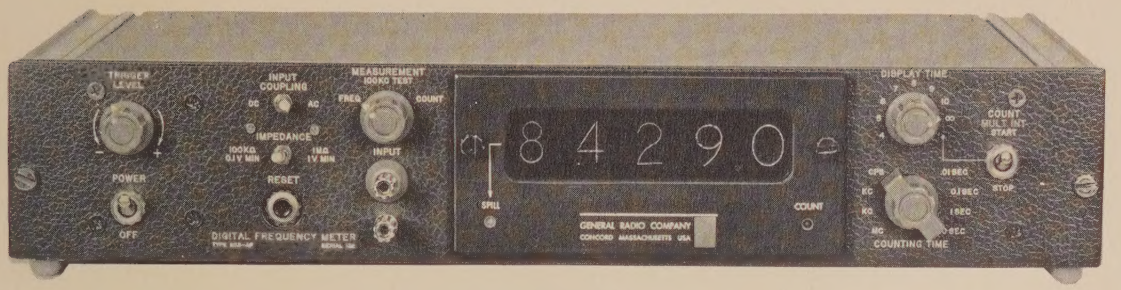
To start the count, set the COUNT/MULT INT switch to START.
To stop the count, set the COUNT/MULT INT switch to STOP.
To clear the register, push the RESET button.

● MULTIPLE-INTERVAL TECHNIQUE

Set controls as follows:

Input controls . . . as required
MEASUREMENT . . for frequency or cumulative-count measurements, as desired.
DISPLAY TIME . . MULT INT
COUNTING TIME . . 1 SEC or 10 SEC (ten seconds is the most practical increment).

To start the count, set the COUNT/MULT INT switch to START and push the RESET button.
To stop the count (assume an interval of 100 seconds is desired), wait a little over 90 seconds, then set the COUNT/MULT INT switch to STOP.
To clear the register, push the RESET button.



● SPECIFICATIONS

INPUT

Frequency: Dc to 10 Mc/s.

Accuracy: ±1 count ± time-base stability.

Sensitivity: 0.1 V, p-to-p, at 100 kΩ and 50 pF; 1.0 V at 1 MΩ and 20 pF. For narrow pulses, 0.1 V at 100 kΩ and >30-ns duration; 0.2 V at 100 kΩ and >15 ns; 1.0 V at 1 MΩ and >30 ns; 2.0 V at 1 MΩ and >15 ns. Max allowable input is ±400 V (at 1 MΩ).

Counting Interval: 0.01, 0.1, 1, or 10 s, extendible by multiplier switch, or as set manually.

Input Trigger: Ac or dc coupled. Trigger level range is ±1 V at 0.1-V sensitivity, ±10 V at 1-V sensitivity. Trigger-level drift is typically 0.05 V, p-to-p, at 0.1-V sensitivity, 0.5 V, at 1-V sensitivity, from 0°C to 50°C.

Self Test: TEST position of measurement switch disconnects input and applies 100 kc/s to check all functions.

DISPLAY 5-digit, in-line readout with decimal point and spill lamp, incandescent-lamp operated. Display time of 0.16, 0.32, 0.64, 1.28, 2.56, 5.12, 10.24 seconds, or infinity.

TIME BASE	*Stability*
100 kc/s, internal or external. Internal frequency derived from 200-kc, GT-cut, room temperature crystal; adjustment provided, adjusted to within 1 ppm when shipped.	**Cycling:** None **Temp Effects:** <6 ppm, 0 to 50°C ambient rise; <±0.1 ppm per °C, 20° to 30°C ambient rise. **Aging:** <0.1 ppm per week.

AUXILIARY CONNECTIONS (rear-mounted connectors)

Time-Base Output: 100 kc/s, 4 V, p-to-p, behind 2 kΩ.

External Time-Base Input: 100 kc/s at 1 V, p-to-p, into 1 kΩ.

Auxiliary Connector: Inputs — reset, start-stop. Outputs — carry pulse from last decade, print command, zero set, 100 kc/s, +20-V test point.

Photoelectric Pickoff Input Connector: 3-terminal telephone jack with +20 V dc and connection to main input.

Data-Output Connector (Type 1153-AP only): 10-line decimal for each digit — one wire binary 1 (+14-V level) and nine wires binary 0 (0 to +4-V level); source impedance 2.4 kΩ; +20-V power; ground; and print-command pulse.

GENERAL

Operating Temp: 0° to +50°C.

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s, 70 W.

Accessories Supplied: TYPE CAP-22 Power Cord, 8 replacement incandescent lamps, spare fuses.

Accessories Available: TYPE 1536-A Photoelectric Pickoff, TYPE 1133-A Frequency Converter and TYPE 1153-P1 Frequency Multiplier to extend range to 500 Mc/s, TYPE 1156-A Decade Scaler to extend range to 100 Mc/s. For TYPE 1153-AP only — TYPE 1136-A Digital-to-Analog Converter, TYPE 1137-A Data Printer, TYPE 1510-A Digital-to-Graphic Recording Assembly.

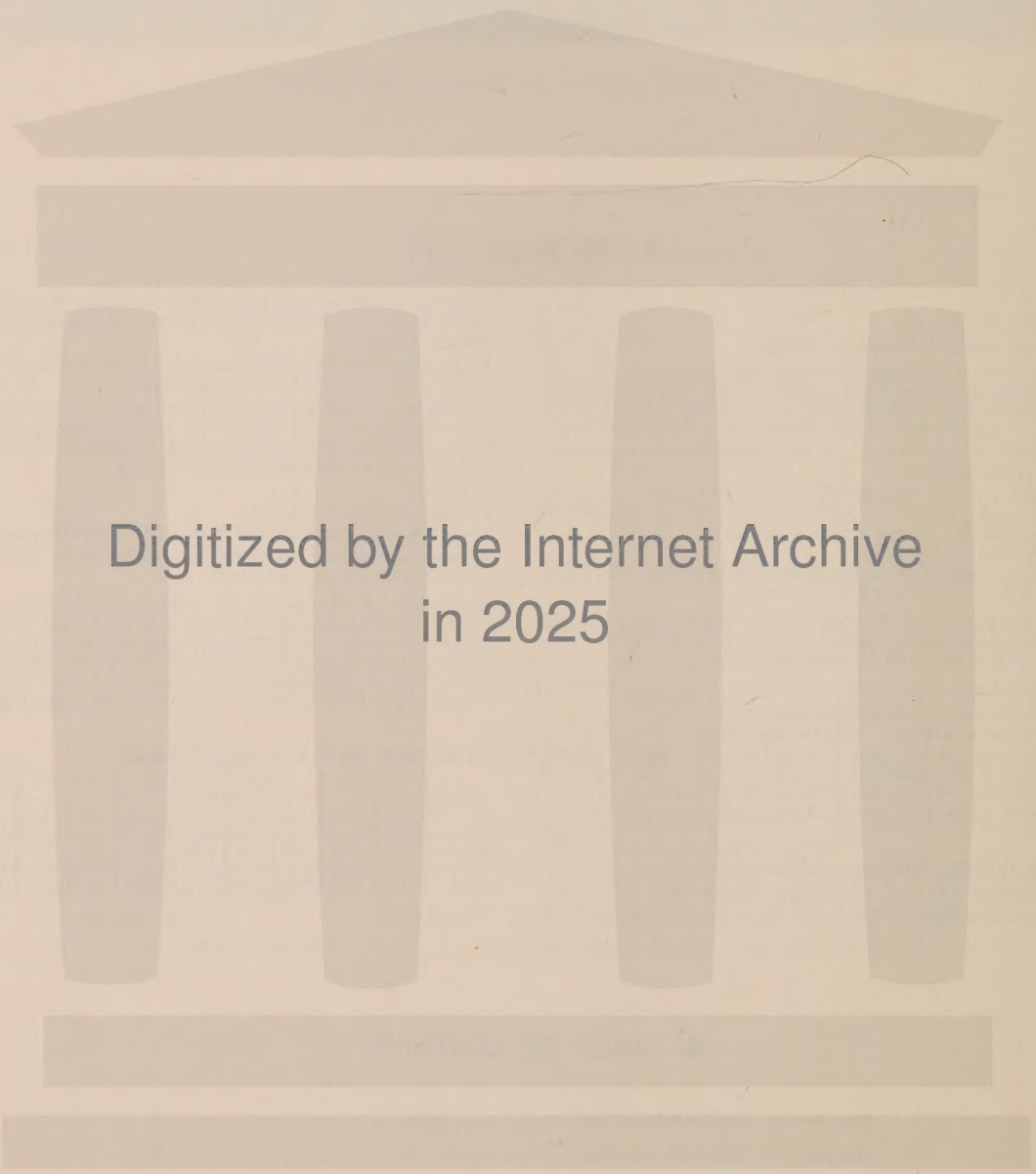
MECHANICAL DATA Rack-Bench Cabinet

Model	*Width*		*Height*		*Depth*		*Net Wt*		*Ship Wt*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	3⅞	99	12½	320	20	9.5	28	13
Rack	19	485	3½	89	11⅝*	298	20	9.5	28	13

* Behind panel.

● TABLE OF CONTENTS

Section 1. INTRODUCTION 1
Section 2. INSTALLATION 5
Section 3. OPERATING PROCEDURE 12
Section 4. PRINCIPLES OF OPERATION 18
Section 5. SERVICE AND MAINTENANCE 24
Section 6. PARTS LIST AND SCHEMATICS 30


Digitized by the Internet Archive
in 2025

https://archive.org/details/manualsplus_05753

SECTION 1

INTRODUCTION

● CONTENTS

1.1 Purpose 1
1.2 Description 1
1.3 Accessories Supplied 1
1.4 Front, Controls and Connectors 2
1.5 Rear, Controls and Connectors 3
1.6 Supplementary Equipment Available 4

● 1.1 PURPOSE

The Type 1153 Digital Frequency Meters are compact, inexpensive laboratory or industrial counters for frequency measurements from dc to 10 Mc/s. With the Type 1156 Decade Scaler, the range is extended to 100 Mc/s, and, with the Type 1133 Frequency Converter, to 500 Mc/s.

The -AP models include data-output provision for use with the Type 1137 Data Printer, the Type 1510 Digital-to-Graphic Recording Assembly, the Type 1136 Digital-to-Analog Converter, and other recording or data-processing equipment.

● 1.2 DESCRIPTION

The instrument measures frequency by counting the number of zero-crossings of the input signal during a time interval established by an internal 100-kc time-base. Provision is also made for an external time-base.

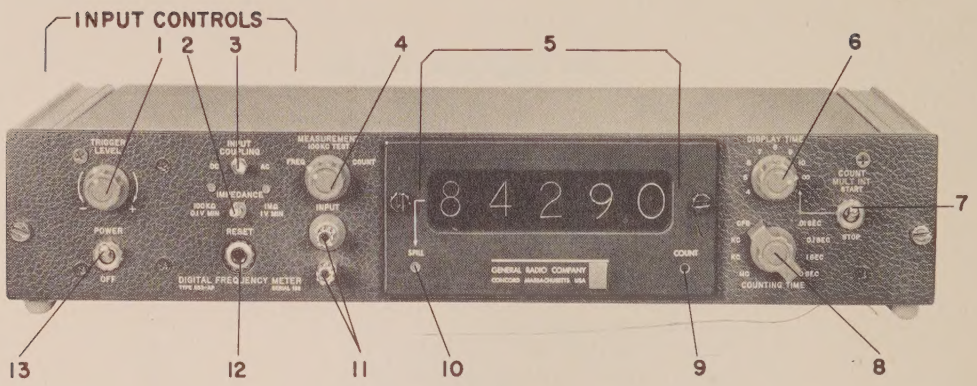
The input controls provide a choice of sensitivity, ac or dc coupling, and triggering level and permit operation with input signals as small as 100 millivolts, peak-to-peak.

The readout includes a spill lamp, which provides an indication when the register capacity has been filled. A stable, GT-cut, room-temperature crystal is incorporated in the time-base oscillator. Since the time-base crystal operates at room temperature, there is no frequency shift due to oven cycling. This is most important when the counter is used with the Type 1133 Frequency Converter for measurements up to 500 Mc/s.

● 1.3 ACCESSORIES SUPPLIED

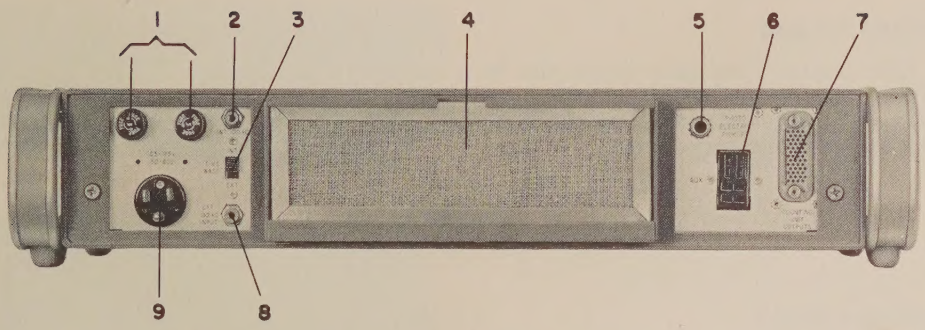
Quantity	*Description*	*Part No.*
1	Instruction book	1153-0100
1	Power cord, 3-wire, Type CAP-22	4200-9622
1	Plug, 8-contact. For connection to AUX connector on rear panel.	4220-5000
2	Fuses, 1 amp for 115-V operation or	5330-1400
	0.5 amp for 215 or 230-V operation	5330-1000
For bench model:		
1	End-frame set	5310-9822
For rack model:		
1	Rack-support set	7860-9602

1.4 FRONT, CONTROLS AND CONNECTORS



1	TRIGGER LEVEL	Continuously adjustable potentiometer. Optimizes the input sensitivity for different input waveforms by offestting the trigger level between +1 and -1 volt (100-kΩ input impedance) or between +10 and -10 volts (1-MΩ input impedance).
2	INPUT COUPLING	Two-position toggle switch. Permits removal of any dc component associated with the input signal. Since the input circuits are dc coupled, a large dc component could prevent a desired, superimposed ac signal from triggering.
3	IMPEDANCE	Two-position toggle switch. Provides a choice of input sensitivities. For most applications the lower input impedance position (100 kΩ) is tolerable and its higher sensitivity (100 mV) is desirable. The higher impedance position (1 MΩ) provides minimum signal loading.
4	MEASUREMENT	Three-position rotary switch. Arranges the instrument circuits for the specified type of measurement.
5	Visual register	Five incandescent-lamp-operated indicators with one-inch-high numerals and gray Polaroid filters; includes decimal points. Provides visual display of measurement.
6	DISPLAY TIME	Nine-position rotary switch. Sets the duration of the display interval from 0.16 to 10.2 second in a binary sequence. When set to ∞, retains any reading until RESET button is pushed. Permits manual counting-time control for count and multiple-interval measurements.
7	COUNT/MULT INT	Two-position toggle switch. Sets the counting time when the MEASUREMENT switch is in the COUNT position. Counting time is manually controlled and is adjustable in increments determined by the COUNTING TIME control when the DISPLAY switch is set to MULT INT.
8	COUNTING TIME	Four-position rotary switch. Establishes a precise interval of 0.01, 0.1, 1 or 10 seconds during which time the input zero crossings are counted.
9	COUNT	Green incandescent lamp. Lights during the counting time.
10	SPILL	Red incandescent lamp. Lights when the capacity of the last (left-hand) indicator has been exceeded.
11	INPUT	Binding-post pair; 3/4-inch spaced. Main terminals for connection of the signal to be measured.
12	RESET	Momentary push-button switch. Terminates the display or counting interval in progress and starts a new counting interval.
13	POWER	Two-position toggle switch. Applies or interrupts the line voltage supplied to the instrument.

● 1.5 REAR, CONTROLS AND CONNECTORS



1	Line fuses	Two 1-A fuses for 115-V operation or two 0.5-A fuses for 215- or 230-V operation.
2	INT 100 kc	Pin jack. Internal 100-kc output from time-base oscillator (4V, p-to-p, behind 2 kΩ).
3	TIME BASE	Two-position slide switch. When set to INT, the time base is provided by the internal oscillator. When set to EXT, the time base is provided by an external 100-kc signal applied to the EXT 100 kc INPUT jack. When no external time base is connected the slide switch should be set to INT. Operation without an external time base and with the switch set to EXT will yield incorrect results.
4	Air filter	Cooling air inlet.
5	PHOTOELECTRIC PICKOFF	Telephone jack. Provides connections to the internal +20 V and main INPUT terminals. For direct connection to an optical transducer such as the General Radio Type 1536-A Photoelectric Pickoff.
6	AUX	Eight-contact Jones-type socket. For connection to auxiliary equipment.
7	COUNTING UNIT OUTPUTS	(Type 1153-AP only.) Fifty-two-contact socket. For connection to printer, digital-to-analog converter, or other data processing equipment.
8	EXT 100 kc INPUT	Pin jack. For connection of an external time-base signal; 100 kc/s at 1 V, p-to-p, minimum, or 200 kc/s at slightly higher input.
9	Power	Three-pin connector. Accepts the Type CAP-22 Power Cord supplied. For connection to power line.

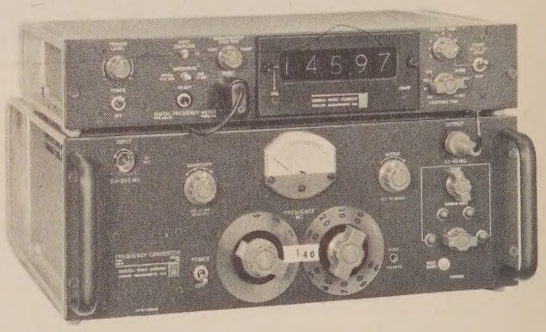
● 1.6 SUPPLEMENTARY EQUIPMENT AVAILABLE

1.6.1 100 Mc/s FREQUENCY RANGE

The Type 1153 Digital Frequency Meter can be used with the Type 1156 Decade Scaler to extend the range to 100 Mc/s. The combination is known as the Type 1144 100-Mc Digital Frequency Meter.

1.6.2 500 Mc/s FREQUENCY RANGE

The Type 1153 Digital Frequency Meter can be used with the Type 1133 Frequency Converter to extend the range to 500 Mc/s. The combination is known as the Type 1143 Frequency Measuring Assembly.

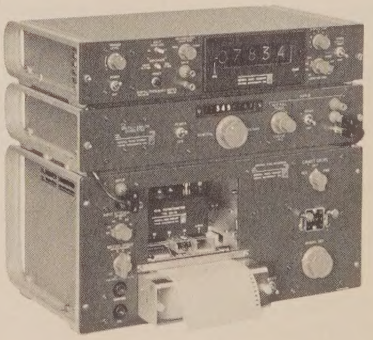


1.6.3 DIGITAL RECORDING

The Type 1153 Digital Frequency Meter, the Type 1144 100-Mc Digital Frequency Meter, or the Type 1143 Frequency Measuring Assembly can be used with the Type 1137 Data Printer to record data permanently in digital form.

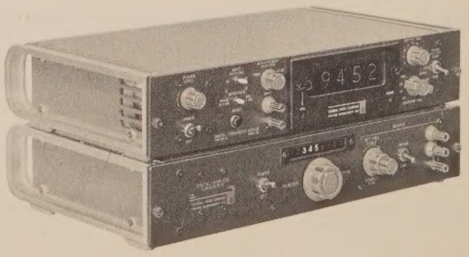
1.6.4 ANALOG RECORDING

The Type 1153 Digital Frequency Meter, the Type 1144 100-Mc Digital Frequency Meter, or the Type 1143 Frequency Measuring Assembly can be used with the Type 1510 Digital-to-Graphic Recording Assembly to record data permanently in analog form. The Type 1510 consists of a Type 1136 Digital-to-Analog Converter and a Type 1521 Graphic Level Recorder.



1.6.5 ANALOG OUTPUT

The Type 1153 Digital Frequency Meter, the Type 1144 100-Mc Digital Frequency Meter, or the Type 1143 Frequency Measuring Assembly can be used with the Type 1136 Digital-to-Analog Converter to convert data to analog form.



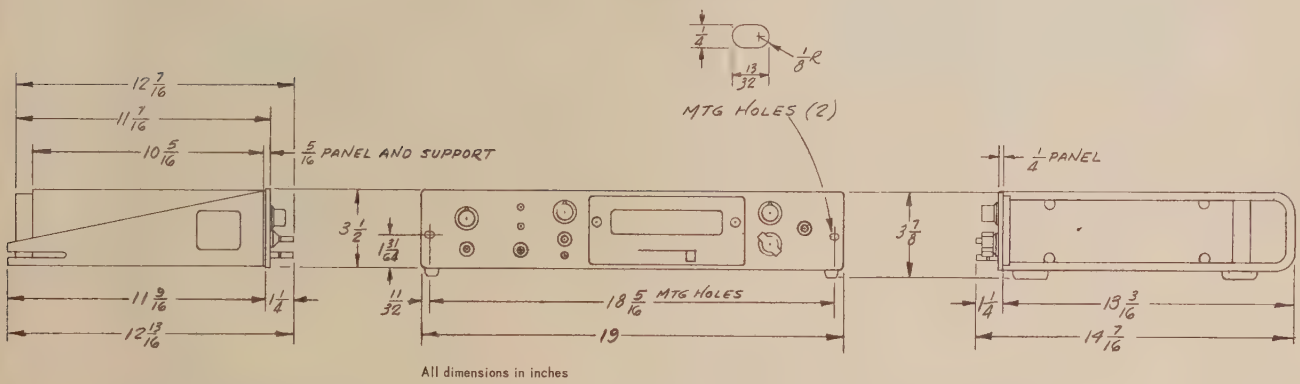
SECTION 2

INSTALLATION

● CONTENTS

2.1 Dimensions 5
2.2 Ventilation 5
2.3 Mounting 6
2.4 Power Connection 8
2.5 Input Signal 9
2.6 Supplementary Connections 10
2.7 Inter-Unit Connections 11

● 2.1 DIMENSIONS



left-hand side (rack mount)

front

right-hand side (bench mount)

● 2.2 VENTILATION

To cool the internal components, air is vented through an air filter at the rear of the instrument to an exhaust fan on the left-hand side. Mount the instrument so that the air flow is not blocked at either the filter or the exhaust port.

● 2.3 MOUNTING

2.3.1 BENCH/RACK CONVERSION

The Type 1153 Digital Frequency Meters are supplied in two models, bench mount and rack mount. Either model may be converted to the other by the installation of a simple conversion set.

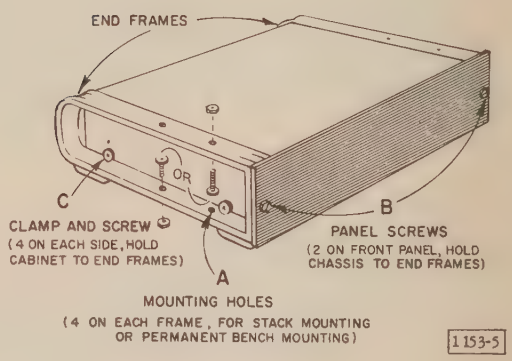
CONVERSION SETS

Model	*Use*	*Conversion Set*
Bench	For bench mounting and stack mounting	7860-9602 rack support set, converts bench model to rack model
Rack	For rack mounting in standard 19-inch relay rack	5310-9822 end frame set, converts rack model to bench model

2.3.2 BENCH MOUNTING (bench model)

The frequency meter normally rests on four rubber feet on top of a bench or shelf. However, holes (A) are provided in each end frame to allow it to be permanently mounted on top or under a bench or shelf.

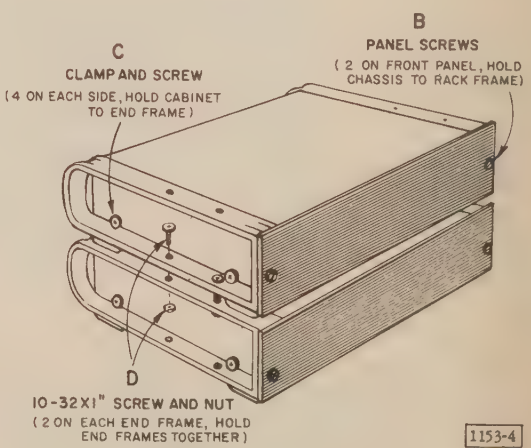
This type of mounting permits either the chassis or the cabinet to be withdrawn independently. To remove the chassis and leave the cabinet mounted, loosen the two panel screws (B) and slide the instrument forward out of the cabinet. To remove the cabinet and leave the chassis mounted, remove the eight clamps and screws (C) and pull the cabinet back off the chassis from the rear of the instrument.



2.3.3 STACK MOUNTING (bench model)

The frequency meter can be permanently assembled with another rack-bench instrument, such as the Type 1156 Decade Scaler or the Type 1133 Frequency Converter, by bolting the end frames together with four 10-32 x 1-inch screws and four 10-32 nuts.

This type of mounting permits the chassis of each instrument to be withdrawn independently. To remove the chassis, loosen the four panel screws (B) and slide the instrument forward out of the cabinet.


B
PANEL SCREWS
(2 ON FRONT PANEL, HOLD CHASSIS TO RACK FRAME)
C
CLAMP AND SCREW
(4 ON EACH SIDE, HOLD CABINET TO END FRAME)
D
10-32 X 1" SCREW AND NUT
(2 ON EACH END FRAME, HOLD END FRAMES TOGETHER)
1153-4

2.3.4 RACK MOUNTING (rack model)

To install the frequency meter in a relay rack, proceed as follows:

a. Attach each support bracket to the rack with two 10-24 binder-head rack screws (E). Use the inside holes on the brackets. Face the bracket lips in.

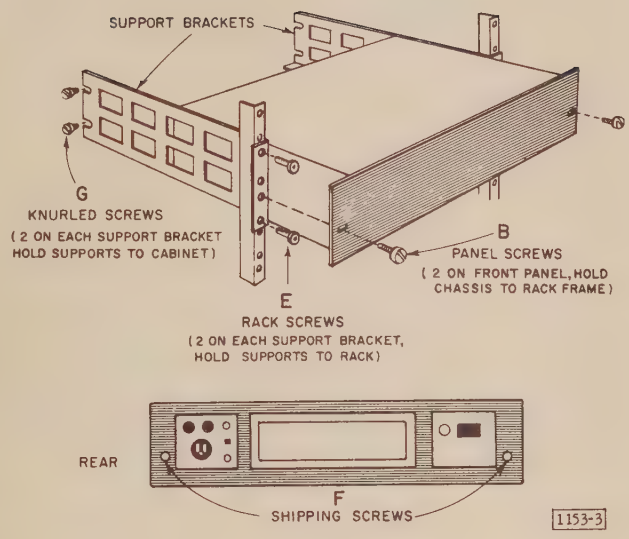
b. Slide the instrument into the brackets as far as it will go.

c. Insert the two panel screws with attached washers (B) through the front panel and support brackets and screw them into the rack. The washers are provided to protect the face of the instrument.

d. At the rear of the instrument, remove the two 10-32 binder-head shipping screws that hold the cabinet to the chassis. These are used only for shipment and can be discarded. Two of the four 10-32 knurled screws (G) can be used to secure the cabinet to the chassis, if necessary, for subsequent reshipments.

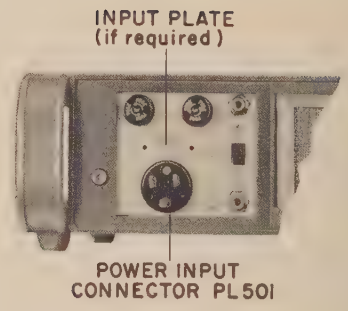
e. Insert the four knurled screws (G) through the slots in the rear of the support brackets and screw them into the cabinet.

This type of mounting permits either the cabinet or the chassis to be withdrawn independently. To remove the chassis and leave the cabinet mounted, loosen the four panel screws (B) and slide the instrument forward out of the rack. To remove the cabinet and leave the chassis mounted, remove the four knurled screws (G) and pull the cabinet back off the chassis from the rear of the rack.



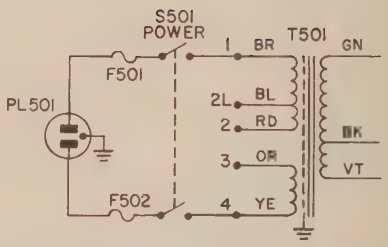
Use the Type CAP-22 Three-Wire Power Cord, provided, to connect the frequency meter to a source of power as indicated on the chassis over the power input connector. The long cylindrical pin (ground) is connected directly to the metal case of the instrument, and hence to the INPUT ground connector on the front panel.

The power transformer is normally wired for 115-volt operation but can be rewired for either 215-volt or 230-volt operation.



2.4.1 115-VOLT LINE

Power required is 105 to 125 V, 50 to 60 c/s, 70 W. No input plate is used, as the input-line voltage data is silkscreened on the rear of the instrument above the power input connector. On the power supply and oscillator etched board, terminal 1 is connected to terminal 3 and terminal 2 to terminal 4. Fuses for F501 and F502 are 1A, part number 5330-1400 each.

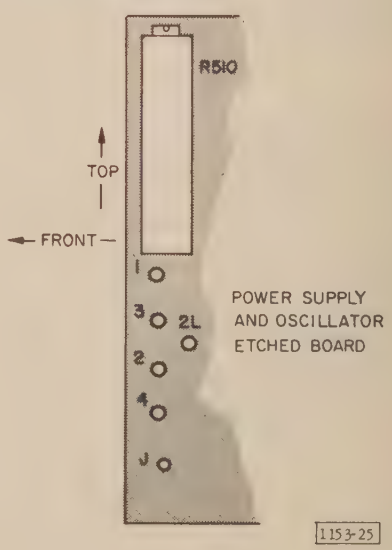


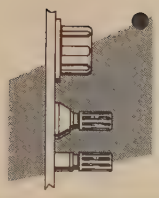
2.4.2 215-VOLT LINE

Power required is 195 to 235 V, 50 to 60 c/s, 70W. An input plate for 215-V operation is used, part number 5590-1668. It attaches to the rear of the instrument, above the power input connector, by means of two 4-40 x 3/16" screws with attached lockwashers, part number 7090-4030, each. On the power supply and oscillator etched board, terminal 2L is connected to terminal 3. Fuses for F501 and F502 are 0.5A, part number 5330-1000 each.

2.4.3 230-VOLT LINE

Power required is 210 to 250 V, 50 to 60 c/s, 70 W. An input plate for 230-V operation is used, part number 5590-1664. It attaches to the rear of the instrument, above the power input connector, by means of two 4-40 x 3/16" screws with attached lockwashers, part number 7090-4030 each. On the power supply and oscillator etched board, connect terminal 2 to terminal 3. Fuses for F501 and F502 are 0.5A, part number 5330-1000 each.

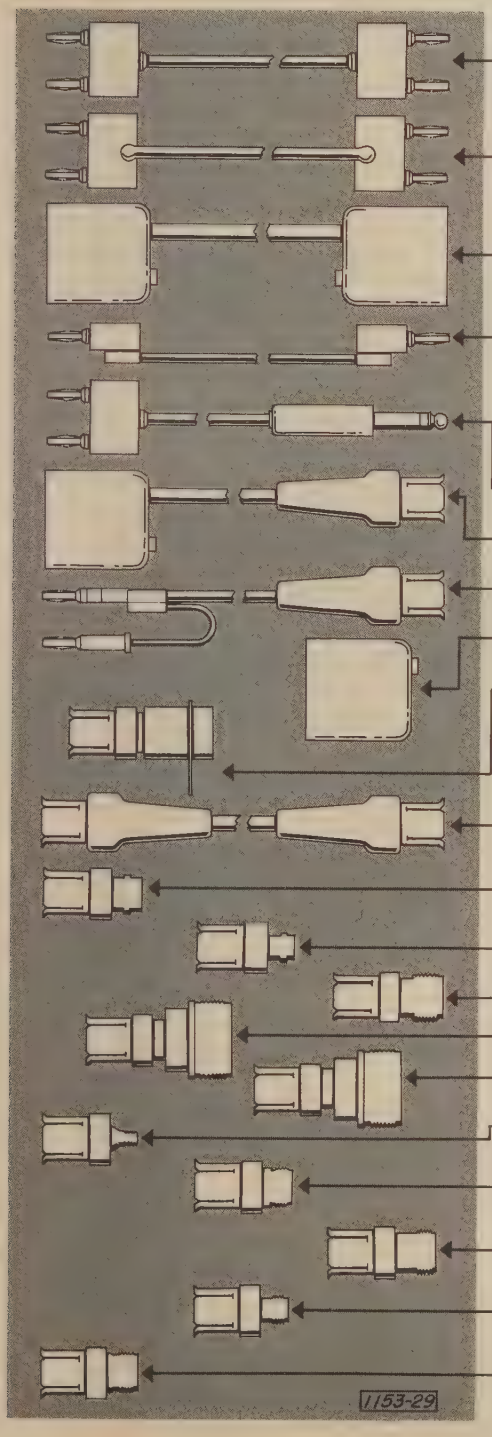




2.5 INPUT SIGNAL CONNECTION.

The INPUT connectors are standard, ¾-inch-spaced binding posts which accept banana plugs, standard telephone tips, alligator clips, crocodile clips, spade terminals, and all wire sizes up to number 10. A wide variety of GR patch cords is also available, as well as a full line of adaptors to convert the INPUT terminals for use with most commercial and military coaxial connectors:

NOTE: GR874 connectors are 50 Ω and are mechanically sexless, i.e., any two although identical, can be plugged together.



274-NQ	Double-plug patch cord, in-line cord, 36" long	0274-9860
274-NQM	Double-plug patch cord, in-line cord, 24" long	0274-9896
274-NQS	Double-plug patch cord, in-line cord, 12" long	0274-9861
274-NP	Double-plug patch cord, right-angle cord, 36" long	0274-9880
274-NPM	Double-plug patch cord, right-angle cord, 24" long	0274-9892
274-NPS	Double-plug patch cord, right-angle cord, 12" long	0274-9852
274-NL	Shielded double-plug patch cord, 36" long	0274-9883
274-NLM	Shielded double-plug patch cord, 24" long	0274-9882
274-NLS	Shielded double-plug patch cord, 12" long	0274-9862
274-LLB	Single-plug patch cord, black, 36" long	0274-9468
274-LLR	Single-plug patch cord, red, 36" long	0274-9492
274-LMB	Single-plug patch cord, black, 24" long	0274-9847
274-LMR	Single-plug patch cord, red, 24" long	0274-9848
274-LSB	Single-plug patch cord, black, 12" long	0274-9849
274-LSR	Single-plug patch cord, red, 12" long	0274-9850
1560-P95	Adaptor cable, double-plug to telephone plug, 36" long	1560-9695
874-R34	Coaxial patch cord, double plug to GR874, 36" long	0874-9692
874-R33	Coaxial patch cord, two plugs to GR874, 36" long	0874-9690
274-QBJ	Adaptor, shielded double plug to BNC	0274-9884
874-Q9	Adaptor, double plug to GR874	0874-9874
874-R20A	Coaxial patch cord, low-loss cable	0874-9680
874-R20LA	Coaxial patch cord, low-loss cable, locking connectors	0874-9681
874-R22A	Coaxial patch cord, general-purpose cable	0874-9682
874-R22LA	Coaxial patch cord, general-purpose cable, locking connectors	0874-9683
874-QBJA	Adaptor, GR874 to Type BNC	0874-9700
874-QBJL	Locking adaptor, GR874 to Type BNC	0874-9701
874-QCJA	Adaptor, GR874 to Type C	0874-9702
874-QCJL	Locking adaptor, GR874 to Type C	0874-9703
874-QHJA	Adaptor, GR874 to Type HN	0874-9704
874-QLJA	Adaptor, GR874 to Type LC	0874-9706
874-QLTJ	Adaptor, GR874 to Type LT	0874-9708
874-QMDJ	Adaptor, GR874 to Type Microdot	0874-9720
874-QMDJL	Locking adaptor, GR874 to Type Microdot	0874-9721
874-QNJA	Adaptor, GR874 to Type N	0874-9710
874-QNJL	Locking adaptor, GR874 to Type N	0874-9711
874-QSCJ	Adaptor, GR874 to Type SC	0874-9712
874-QSCJL	Locking adaptor, GR874 to Type SC	0874-9713
874-QTNJ	Adaptor, GR874 to Type TNC	0874-9716
874-QTNJL	Locking adaptor, GR874 to Type TNC	0874-9717
874-QUJ	Adaptor, GR874 to Type UHF	0874-9718
874-QUJL	Locking adaptor, GR874 to Type UHF	0874-9719

● 2.6 SUPPLEMENTARY CONNECTIONS

A Time-Base Output

At the INT 100-kc phono jack on the rear of the instrument, 100 kc/s, 4V, p-to-p, behind 2 kΩ, is available from the internal 100-kc oscillator for driving accessory equipment.

B External Time-Base Input

An external 100-kc or 200-kc signal can be used as a reference source in place of the 100-kc signal from the crystal oscillator of the Type 1153. Apply the signal to the EXT 100 kc INPUT phono jack at the rear of the instrument and set the TIME BASE switch to EXT. The external 100-kc source should be capable of providing 1V, p-to-p, into 1 kΩ (slightly higher voltage required at 200 kc/s).

C Photoelectric Pickoff Input

The PHOTOELECTRIC connector is a 3-terminal telephone jack. One terminal is connected to +20V dc from the instrument's power supply and the other two terminals are connected in parallel with the INPUT terminals.
This jack is provided for direct connection to a General Radio Type 1536 Photoelectric Transducer. The transducer has a light source and a photoconductor which convert changes in reflection of the light source into electrical input signals. For instance, when the transducer is placed in the path of a piece of reflecting tape on a rotating object, with the COUNTING TIME switch set to 1 SEC, the frequency meter indicates revolutions per second. Since the photoelectric pickoff signal is in parallel with the INPUT terminals, no signal should be connected to the INPUT terminals.

D Printer/Converter Connection (Type 1153 only)

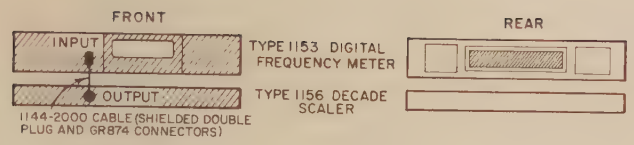
An eight-contact, Jones-type socket (AUX) on the rear of the instrument is provided for connection to auxiliary equipment. It has the following characteristics:

Pin	*Signal*	*Characteristic/Purpose*
1	Ground	To ground of the external system.
2	Reset	To feed a reset signal from an external system into the Type 1153. The reset signal can be achieved by applying a negative-going pulse from a pulse generator or by momentarily grounding pin 2 through a switch.
3	Carry	A negative 14-V pulse which represents the 9-to-0 transition in the last decade. It should be capacitively coupled, if used, as an overload can cause errors in the instrument operation and a direct short can cause permanent damage.
4	Print Command	A negative 20-V pulse which occurs when the counting gate closes. It will drive a printer or a Type 1136 Digital-to-Analog Converter.
5	Zero-Set Pulse	A negative 20-V, 500-μs pulse which indicates the main gate will open in the next 10 ms. It can be used to start auxiliary equipment and should be capacitively coupled.
6	Gate	Electrically simulates COUNT/MULT INT switch operation. Set the COUNT/MULT INT switch to STOP. Apply a positive, 20 to 30-V signal to pin 6 to open the gate (simulate START position of COUNT/MULT INT switch).
7	20 V	Positive, regulated 20 V; 100 mA maximum.
8	100 kc/s	7-V, p-to-p, 100-kc square waves.

E Auxiliary Equipment

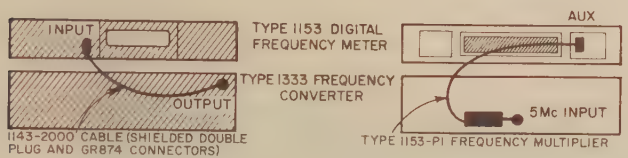
The 52-pin connector, labeled COUNTING UNIT OUTPUTS, on the rear of Type 1153-AP models, provides voltages necessary to drive a printer, converter, or other accessory equipment.
The output consists of 10-line decimal information for each digit (one wire binary 1 at a +14-V level and 9 wires binary 0 at a 0 to + 4-V level, each behind 2.4 kΩ), +20-V power, ground, and a print command pulse.

2.7 INTER-UNIT CONNECTIONS



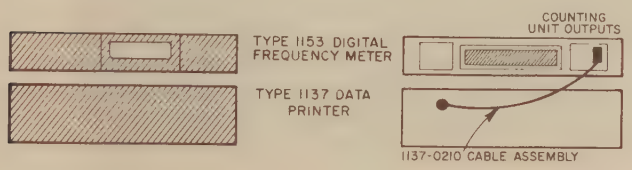
2.7.1 100 Mc/s FREQUENCY RANGE

Connections to Type 1156 Decade Scaler



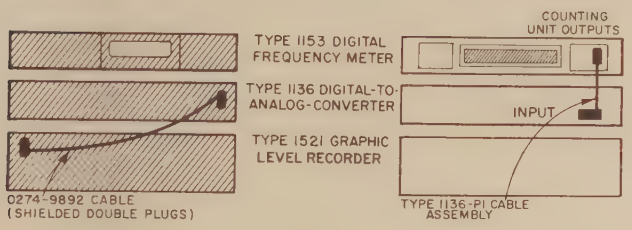
2.7.2 500 Mc/s FREQUENCY RANGE

Connections to Type 1133 Frequency Converter



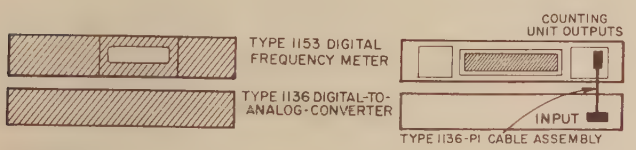
2.7.3 DIGITAL RECORDING

Connections to Type 1137 Data Printer



2.7.4 ANALOG RECORDING

Connections to Type 1510 Digital-to-Graphic Recording Assembly or
Type 1136 Digital-to-Analog Converter and
Type 1521 Graphic Level Recorder



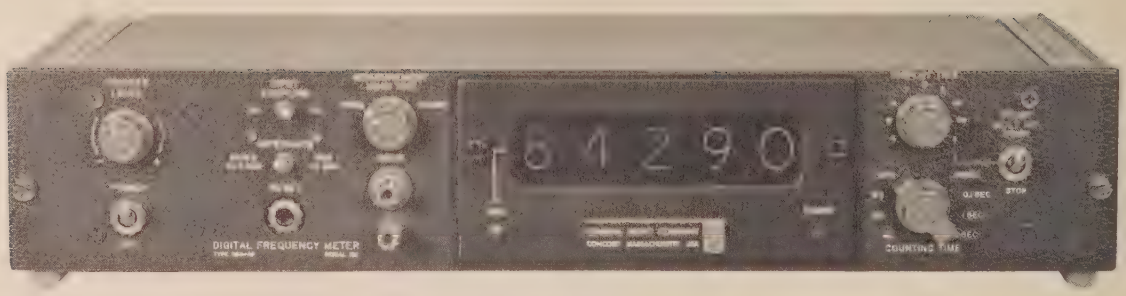
2.7.5 ANALOG OUTPUT

Connections to Type 1136 Digital-to-Analog Converter

1153-11

SECTION 3

OPERATING PROCEDURE



● CONTENTS

3.1 Preliminary 12
3.2 Check 13
3.3 Frequency Measurement 13
3.4 Cumulative-Count Measurement 14
3.5 Multiple Interval Technique 14
3.6 Noise and Waveform Considerations 15
3.7 Accuracy 17

● 3.1 PRELIMINARY

Connect the instrument to a source of power and turn the POWER switch on. If the internal time-base is to be used, set the rear TIME BASE switch to INT. If an external time base is to be used, connect an external 100-kc source to the rear EXT 100 kc INPUT connector and set the rear TIME BASE switch to EXT.

3.2 CHECK

Set controls as follows

TRIGGER LEVEL. . . centered
INPUT COUPLING. . . AC
IMPEDANCE . . . . . 100 kΩ
MEASUREMENT . . . 100 kc TEST
DISPLAY TIME . . . . 6 or 7
COUNTING TIME. . . 0.1 SEC

The instrument is now counting its own 100-kc time base for a tenth of a second and the display should read 100.00. With the COUNTING TIME switch set to 0.01 SEC the display should read 0.1000 and with it set to 1 SEC or 10 SEC the display should read 00000 and the SPILL lamp should be lit.

3.3 FREQUENCY MEASUREMENT

Set controls as follows:

TRIGGER LEVEL
INPUT COUPLING
IMPEDANCE } . as required, see pages 15, 16.
MEASUREMENT . . . FREQUENCY
DISPLAY TIME . . . as required

Setting	*Display Time*
4	0.16 second
5	0.32
6	0.64
7	1.28
8	2.56
9	5.12
10	10.24
∞	Indefinitely or until RESET button is pushed.

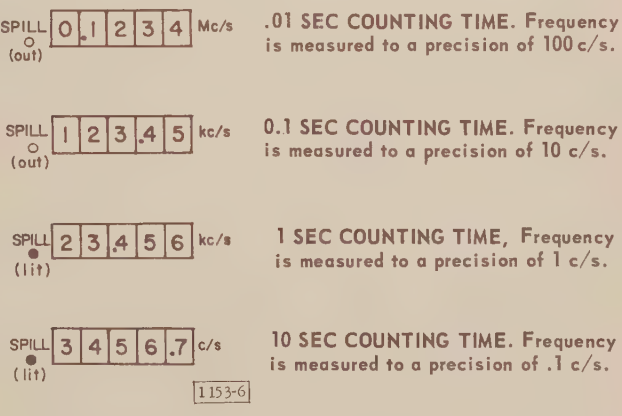
COUNTING TIME. . . .01 SEC

The self-check signal is removed from the INPUT terminals and the instrument is ready for frequency measurements of an external signal.

When the DISPLAY TIME switch is set to one of the numbered positions and the TRIGGER LEVEL control is properly set, the instrument will automatically measure the frequency, alternately counting (COUNT lamp lit) and displaying (indicators lit).

The COUNTING TIME switch has the effect of windowing the display from the five most significant figures to the five least significant figures:

For example: Assume the frequency of the input signal is 123,456.7 cycles per second.


SPILL (out)
0 .1 2 3 4 Mc/s
.01 SEC COUNTING TIME. Frequency is measured to a precision of 100 c/s.
SPILL (out)
1 2 3 .4 5 kc/s
0.1 SEC COUNTING TIME. Frequency is measured to a precision of 10 c/s.
SPILL (lit)
2 3 .4 5 6 kc/s
1 SEC COUNTING TIME, Frequency is measured to a precision of 1 c/s.
SPILL (lit)
3 4 5 6 .7 c/s
10 SEC COUNTING TIME. Frequency is measured to a precision of .1 c/s.
1153-6

Thus, the frequency of any input signal from dc to 10 Mc/s can be measured to a precision of 0.1 c/s.

● 3.4 CUMULATIVE-COUNT MEASUREMENT (operation as a totalizer)

Set controls as follows:

TRIGGER LEVEL, INPUT COUPLING, IMPEDANCE . . . as required, see pages 15,16.
MEASUREMENT . . . COUNT
DISPLAY TIME . . . any position, 0 through ∞
COUNT/MULT INT . . START

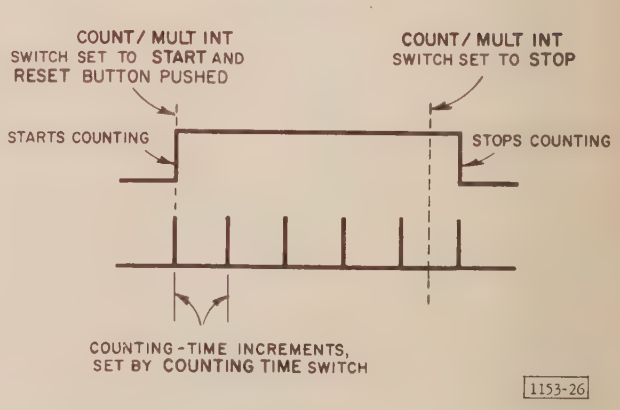
The COUNT/MULT INT switch now controls the counting time; in the START position the instrument counts and in the STOP position it does not count. The count, accumulated during the time the COUNT/MULT INT switch is in the START position, remains on the visual register until the RESET button is pushed.

The function of the COUNT/MULT INT switch can be remote-controlled through the auxiliary connector (AUX, SO801 pin 6) on the rear panel. Refer to page 10 for further details.

● 3.5 MULTIPLE-INTERVAL TECHNIQUE (increases measurement precision)

Frequency measurements and cumulative-count measurements can be made by use of the multiple-interval technique which provides greater measurement precisions than are possible with the longest, normal counting time of 10 seconds. This technique allows the counting time to be set for any duration desired, in increments determined by the COUNTING TIME switch. The counting time can be set for 100 seconds, for instance, which would yield a precision of 0.01 c/s, an order of magnitude better than the normal 0.1 c/s.

For example, a 10-second measurement of a particular frequency is not sufficiently accurate and a 50-second measurement is desired. Set all controls as they would be in a normal frequency measurement. Then set the DISPLAY TIME control to MULT INT, the COUNTING TIME control to 10 SEC and the COUNT/MULT INT switch to START. Push the RESET button to start the count, wait a little over 40 seconds, and then set the COUNT/MULT INT switch to STOP, the count will stop at a counting time of 50 seconds and will be displayed on the visual register indefinitely or until the RESET button is pushed.

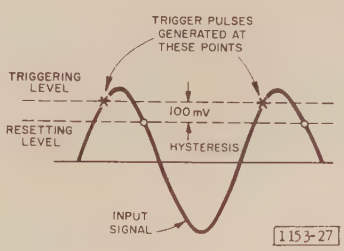


In principle, the counting-time increments can be 0.01, 0.1, 1, or 10 seconds. In practice, since the technique involves manual operation of the COUNT/MULT INT switch, the shortest possible increment is one second and the most practical increment is 10 seconds.

● 3.6 NOISE AND WAVEFORM CONSIDERATIONS

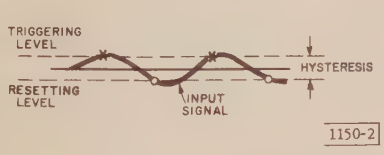
3.6.1 TRIGGER CIRCUIT

The trigger circuit consists of two, dc-coupled, differential amplifiers cascaded to a tunnel diode. This circuit is very similar to the well-known Schmitt circuit and exhibits the hysteresis effect. That is, after the circuit has triggered to form a counted pulse on a positive-going transition of the input signal, the input signal must then swing to a less positive level to reset the circuit. The hysteresis in the Type 1153 is approximately 100 mV.



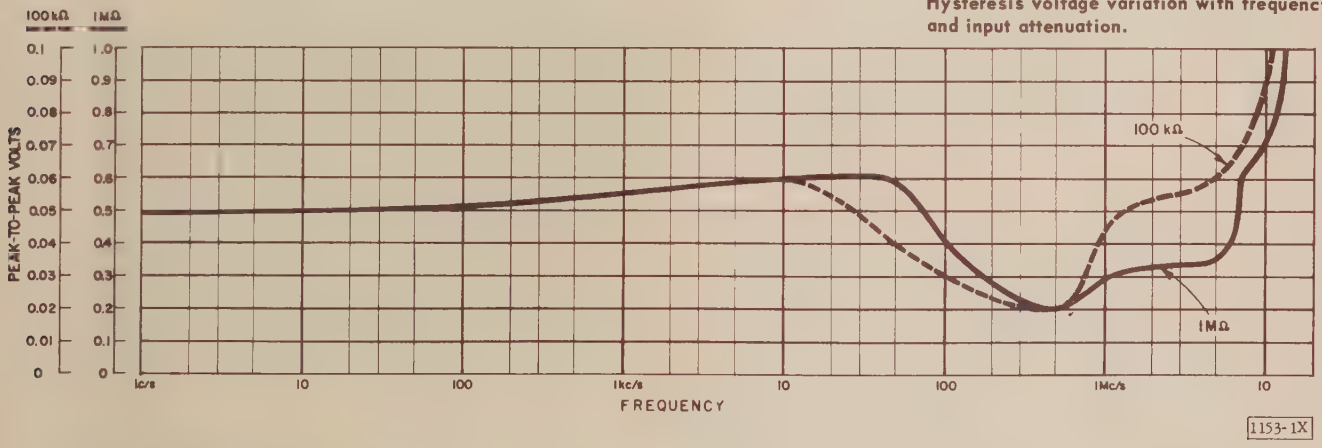
3.6.2 TRIGGER SENSITIVITY

The input sensitivity of the instrument is determined by the trigger circuit's hysteresis voltage. This voltage varies to some extent with frequency and varies directly with input attenuation (IMPEDANCE switch setting).



Minimum input signal required to drive counter.

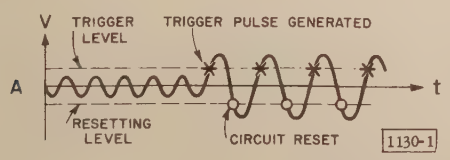
Hysteresis voltage variation with frequency and input attenuation.



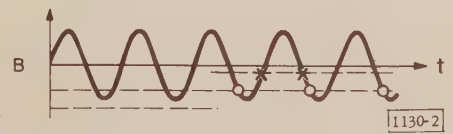
3.6.3 INPUT CONTROLS

Low-duty-ratio, ac-coupled signals or non symmetrical (about 0 volts) dc-coupled signals require a trigger level that is offset from 0 volts. The TRIGGER LEVEL control provides this offset and allows adjustment of the trigger level from +10 to -10 volts with a 1-MΩ input impedance and from +1 to -1 volt with a 100-kΩ input impedance.

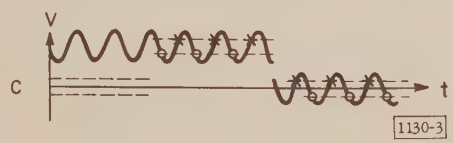
Some of the characteristic input-signal problems and their solutions by correct use of the input controls are shown in the adjacent figures.



Signal too small; must be increased

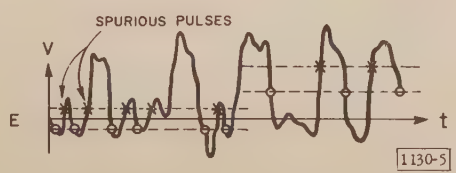


Too large a negative offset of the TRIGGER LEVEL control. Corrected by reducing offset.



DC component of signal lifts ac component out of triggering region. Corrected either by raising triggering level or by setting SLOPE control to AC.

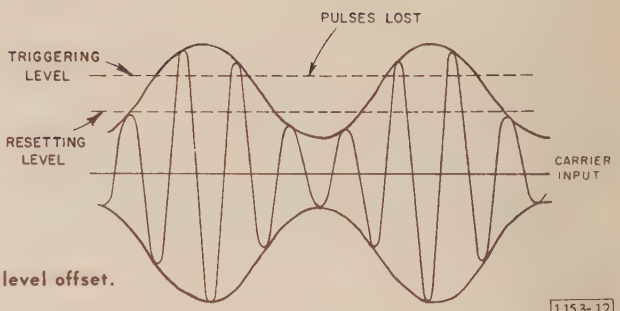
Low duty-ratio pulse signal. Corrected by raising triggering level.



Pulse signal with added noise. Corrected by setting triggering level to region of steepest slope.

3.6.4 AMPLITUDE MODULATION ERRORS

If the signal to be measured is amplitude-modulated, measurement errors may occur if the TRIGGER LEVEL control is offset from 0 as shown in the adjacent figure. With the control at 0, the correct frequency will be measured as long as the minimum value of the signal is greater than that necessary to drive the Type 1153.



AM error with trigger level offset.

3.6.5 EXCESSIVE INPUT-FREQUENCY ERRORS

The Digital Time and Frequency Meter measures the average value of an unknown frequency during the chosen counting interval, as long as the frequency remains within the resolution capability of the instrument. If the unknown frequency exceeds 10 Mc/s, counts may be missed and the measurement may be in error.

3.6.6 SPURIOUS SIGNAL AND NOISE ERRORS

If the desired signal is accompanied by enough noise to cause extra transitions of the hysteresis region, false counts will be registered. To combat this error, adjust the TRIGGER LEVEL control to the region of steepest slope or attenuate both the signal and noise.

Occasionally it is necessary to measure the frequency of a signal in the presence of another signal of nearly equal amplitude. A capture effect exists in the Type 1153, similar to that encountered in frequency-modulation receivers. If the two signals, are nearly equal in frequency, the instrument measures the signal with the larger amplitude if its peak-to-peak amplitude exceeds that of the other signal by the hysteresis voltage of the Type 1153. If the signals differ in frequency the following relationships apply:

Type 1153 measures the higher frequency if $V_h > V_\ell + \Delta$

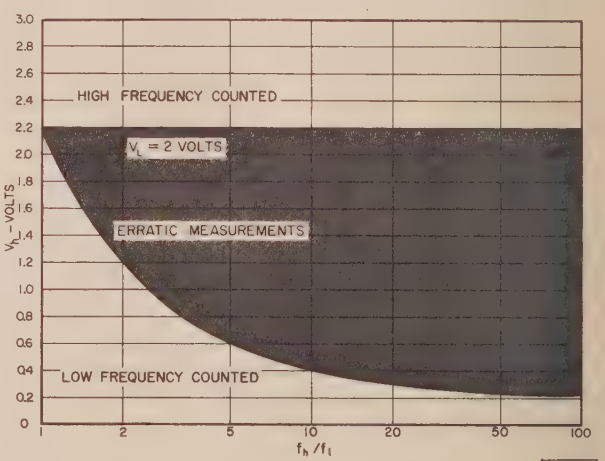
Type 1153 measures the lower frequency if $V_h < \frac{f_\ell}{f_h} V_\ell + K\Delta$

Where V_h = peak-to-peak amplitude of higher frequency signal

V_ℓ = peak-to-peak amplitude of lower frequency signal

f_h = higher frequency

Conditions for measuring a signal in the presence of another signal of nearly equal amplitude.



f_ℓ = lower frequency

Δ = hysteresis voltage of counter

K = a factor varying between 1 and 2

If neither condition is satisfied, the instrument will give erroneous readings. These conditions are illustrated in the adjacent figure.

● 3.7 ACCURACY

3.7.1 GENERAL

There are two fundamental sources of error:

NOISE: Noise may be caused by drift, hum pickup, the input signal itself, or the triggering level. Its effects are discussed in the preceeding paragraphs (Spurious Signal and Noise Errors).

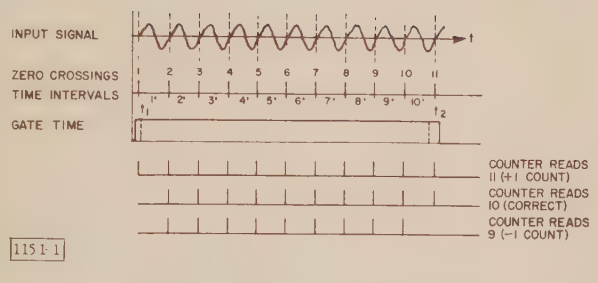
±1 COUNT UNCERTAINTY: This uncertainty occurs through the gating process and is explained below.

3.7.2 ±1 COUNT UNCERTAINTY

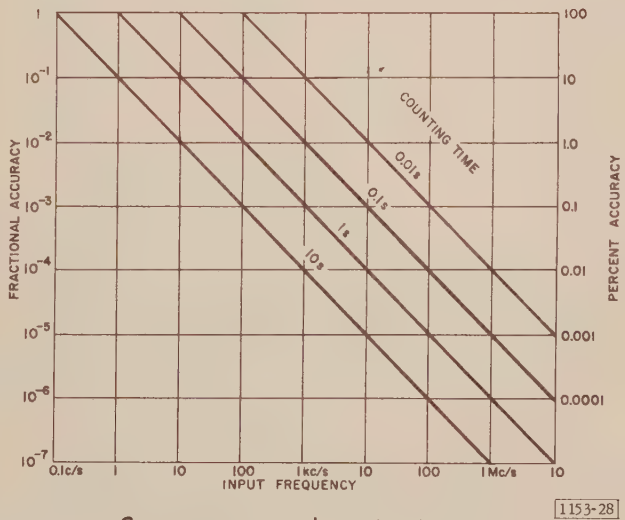
In all digital counters, frequency is measured in terms of pulses representing the signal zero crossings within an accurately established time interval. What we would like to measure to define the frequency would be the precise number of time intervals representative of the unknown frequency that occur within an accurate interval, but this is not possible. The conditions for a +1 count, an accurate measurement, and a -1 count are shown in the upper figure. Note that we assume that the pulses representative of the input signal are infinitely brief and that the gate is infinitely fast. Pulse duration and gating time do not cause the ±1-count error.

In the upper figure an input signal of 10 units of frequency with respect to the gate is used. The important quantity in the measurement is the 10 time intervals. 1′ through 10′. Suppose that the gate opens just before pulse number 1. The counter's register accumulates a count and indicates 1, but no time interval has elapsed. If the gate then closes just after the 11th pulse the register reads 11, representative of only 10 units. If the gate opens a very small amount of time (t_1) later, the first pulse is not counted and the register indicates the nearly correct value of 10. If the duration of the gate is shortened again by a very small time increment, t_2, the 11th pulse is not counted and the register reads only 9. The ±1-count error is, therefore, an inescapable result of trying to measure time intervals with pulses representing their beginnings and ends.

The lower figure shows how the ±1-count error affects measurement accuracy. The longer one counts, the more accurate the measurement will be, since more and more pulses are accumulated, with the ±1-count error constant. Thus at 1 kc/s, for instance, the error will be 10% for a 0.01-second gate and only 0.01% for a 10-second gate.



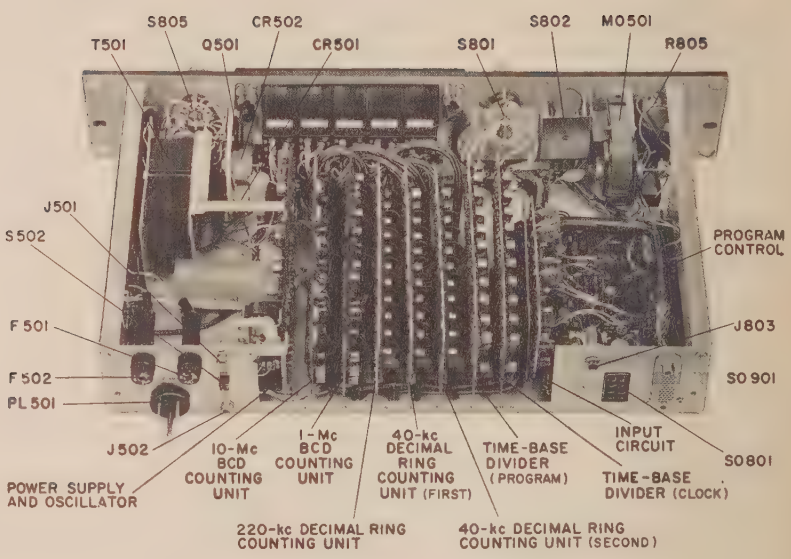
Mechanism of the ±1-count uncertainty.



Counter accuracy and counting time as defined by the ±1-count uncertainty.

SECTION 4

PRINCIPLES OF OPERATION



● CONTENTS

4.1 General 18
4.2 Count Measurement 19
4.3 Frequency Measurement 19
4.4 1-Mc and 10-Mc BCD Counting Units 20
4.5 220-kc and 40-kc Decimal Ring Counting Units . 21
4.6 Time-Base Oscillator 21
4.7 Time-Base Dividers 22
4.8 Program Control 23
4.9 Power Supply 23

Information on the input triggering circuit is contained in Section 3, page 15.

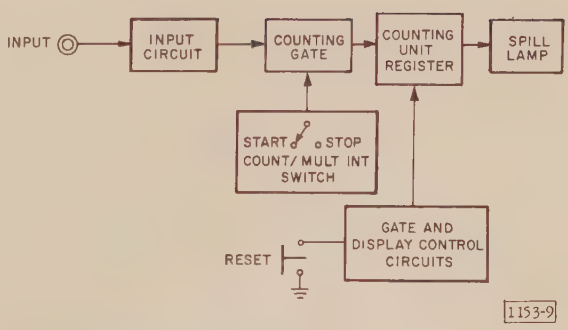
● 4.1 GENERAL

The Type 1153 consists of four main circuit groups:

1. Oscillator circuit and its associated time-base divider (clock scaler).
2. Input circuit.
3. Counting circuits (one 10-Mc and one 1-Mc Decimal Counting Unit and two 220-kc and two 40-kc Decimal Ring Counting Units).
4. Display control and its associated time-base divider (program scaler).

4.2 COUNT MEASUREMENT

In the COUNT position of the MEASUREMENT switch, a single pulse per cycle of the input waveform is formed by the input circuits and is either passed or blocked by the counting gate. The counting gate is controlled by dc signals from the COUNT/MULT INT switch. When the gate is closed, the displayed count in the register is simply equal to the number of pulses accumulated during the gate-open time. The counting register is cleared to zero when the RESET button is pushed, and the only function of the gate and display-time logic is to provide the reset pulse.

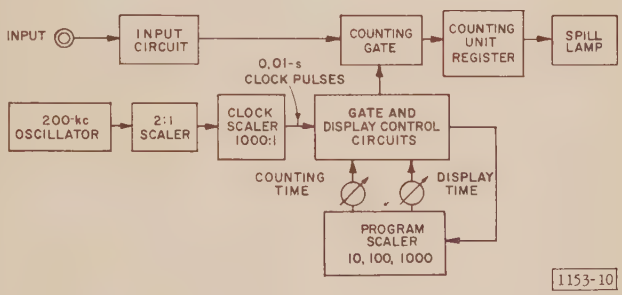


Circuit logic for count measurements

4.3 FREQUENCY MEASUREMENT

In the FREQUENCY position of the MEASUREMENT switch, the function of the input circuits is the same as for COUNT measurement. The counting gate, however, is now controlled by the gate and display control circuits. For accurate measurement of frequency, the counting gate must be open for an accurately controlled time interval. The result is displayed (for a period to suit the operator's convenience), and then the counting register is set to zero so that a new measurement can be made. In the Type 1153 counters all three intervals, counting, display, and reset, are under full control of the quartz-crystal oscillator.

The 200-kc oscillator output is fed to a 2:1 scaler. The 100-kc output of this scaler is fed through the clock scaler which divides by a factor of 1000. The resulting 100-cycle signal from this scale-of-1000 divider (clock scaler) forms the master "clock" for the counting process. Let us assume that the instrument has just been reset to zero. The next 100-cycle clock pulse opens the main gate and pulses corresponding to the period of the input signal are admitted to the counting register. Simultaneously, the second scale-of-1000 divider (program scaler) begins to accumulate clock pulses. If a one-second gate time has been set with the COUNTING TIME switch, the program scaler will accept 100 clock pulses. The 100th clock pulse will close the main gate, set the program scaler to zero, and start the display interval. This interval is also determined by the program scaler. The clock pulses are counted by the program scaler in a purely binary sequence. For instance, if 16 pulses are counted (DISPLAY TIME switch set to 4) the display interval will last for 0.16 second; 32 pulses counted (DISPLAY TIME switch set to 5) will establish a 0.32-second display, and so on, up to 1024 pulses (DISPLAY TIME switch set to 10), which establishes a 10.24-second display time. The last clock pulse during the display time

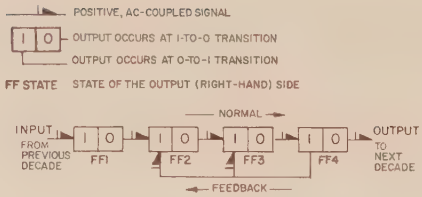


Circuit logic for frequency measurements

is fed back from the program scaler to the control circuits through the DISPLAY TIME switch. The signal from this switch terminates the display interval, generates the reset pulse, and the measurement cycle then repeats. Note that all phases of the measurement are under complete control of the clock so that this program could be termed completely synchronous.

To obtain infinite display time, the display path from the program scaler can be opened (DISPLAY TIME switch set to ∞). The display will be retained until the instrument is manually reset. Multiple-interval measurement is also controlled by the DISPLAY TIME switch. With the switch in this position, the COUNT/MULT INT switch is placed in the gate time circuit. When the COUNT/MULT INT switch is set to START, the pulse from the program scaler that normally closes the counting gate is interrupted. The gate will close at the end of the time interval after the COUNT/MULT INT switch has been set to STOP. Thus gate intervals of 1, 2, 3 ...n seconds, or 10, 20, 30 .....n tens seconds can be manually established.

4.4.1 DECADE LOGIC

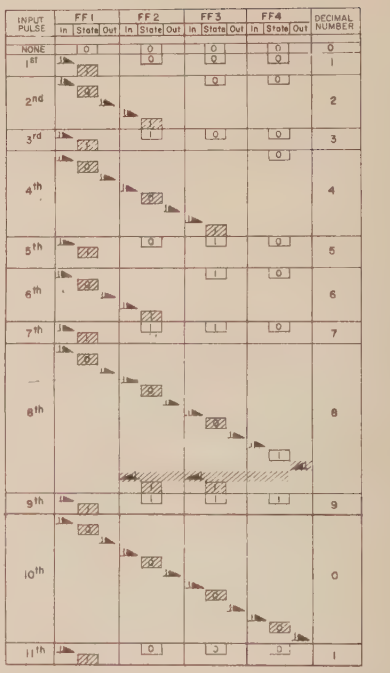


The 1-Mc and 10-Mc counting units are binary decades composed of four cascaded flip-flops. Each flip-flop is in either a binary 0 or a binary 1 state and the state changes upon receipt of an input pulse. To achieve division by 10 (decade counting), the output of the fourth flip-flop is fed back to the input of the second and third.

The counting action is shown in the adjacent diagram; the highlights are described below:

Normal pulses occur when a flip-flop changes from the 1 to the 0 state and feedback pulses occur when the flip-flop changes from the 0 to the 1 state.

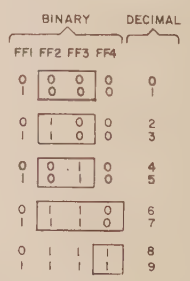
The eighth input pulse to the decade causes the fourth flip-flop to send a feedback pulse to the second and third flip-flops. Therefore, the eighth pulse sets the last three flip-flops to 1, the ninth pulse sets all flip-flops to 1, and the tenth pulse sets all flip-flops to 0 and causes an output pulse. Note that it takes 10 input pulses to produce one output pulse.



1153-2X

4.4.2 DECIMAL MATRIX

Binary information from the flip-flops is applied to a biquinary matrix where it is converted to decimal information and used to drive the indicator lamps. Five decimal pairs are contained in the numbers 0 through 9 and a unique combination of states from the flip-flops exist for each pair The state of flip-flop 1 determines whether the even or odd number of the pair is selected, hence the term biquinary.



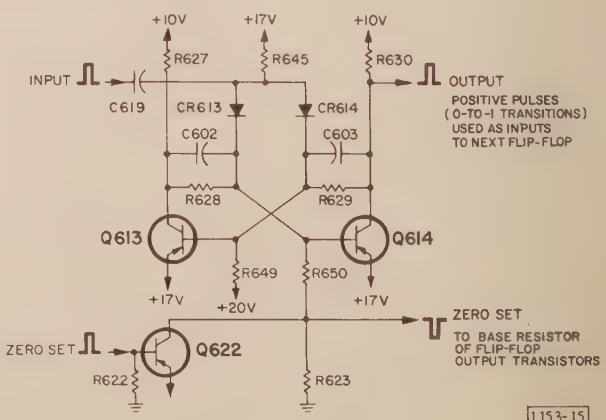
1153-7

4.4.3 FLIP-FLOP CIRCUIT

QUIESCENT: Each flip-flop is comprised of two pnp transistors, which require a negative base (to emitter) voltages for conduction. The zero-set transistor, Q622, is normally conducting, and its collector rests at about +20 volts so that the base resistors, R649 and R650, of the flip-flop transistors are returned to the same potential. Assume the flip-flop is in the 0 state; i.e., its output transistor, Q614, is in the 0 state (conducting).

SWITCHING: A positive input pulse is applied to CR613 and CR614, which starts the normal multivibrator regenerative action as follows: the positive pulse is fed through CR614 at the base of Q614 and turns Q614 off. As Q614 turns off, its collector voltage drops from +17 volts to +10 volts. This negative transition is coupled through C603 to the base of Q613 and turns Q613 on. As Q613 turns on, its collector voltage increases from +10 volts to +17 volts, this positive transition is coupled through C602 to the base of Q614 and further turns Q614 off. The flip-flop has changed states from 0 to 1. The next input pulse will change the state from 1 to 0.

ZERO SET: A positive pulse applied to the base of Q622 (zero-set pulse) is inverted and applied to the base of the output transistors in the flip-flops. This negative pulse turns the output transistors on and thus sets all flip-flops to the 0 state.

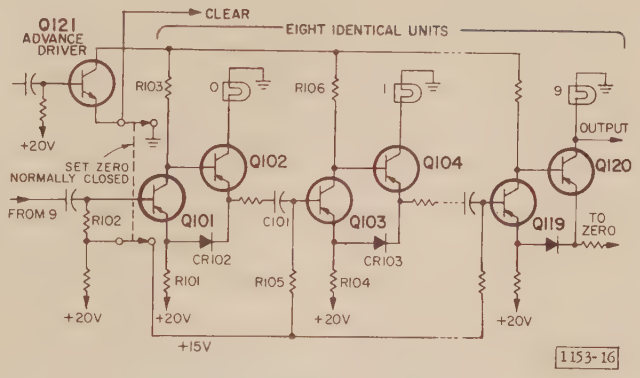


1153-15

● 4.5 220-kc AND 40-kc DECIMAL RING COUNTING UNITS

Each unit contains a ring of 10 bistable circuits. Each bistable circuit has one "high-current" transistor capable of driving the associated incandescent lamp for that decades indicator.

Assume the counting unit has been set to its zero state. Q101 is off and Q102 is on. Q102, with base forward bias current provided by R103, is kept saturated and passes 80 mA to light the zero lamp in the indicator. This 80-mA current produces a voltage drop of 5.5 volts across R101. The base of Q101 is returned via R102 to the set-zero buss voltage of about 15 volts. The base of Q101 is, therefore, reverse-biased with respect to the emitter and Q101 remains off. The circuit is stable in this state. All other pairs in the ring have the opposite stable state. The left-hand transistors (Q103, etc) are on, and all right hand transistors (Q104, etc) are off. Q103, for example, is on and has nearly 1 mA of forward drive. Since the drop across the 68-ohm resistor (R104) on the common emitter is only 0.07 volt, the full 20-volt collector-supply voltage appears across R106. The very small drop in emitter-to-collector voltage of Q103 will normally be below the conduction knee-voltage of Q104 and will keep it off. Complete cutoff of Q104 for all possible transistor combinations at elevated temperature is ensured by the silicon diode (CR103 in series with the emitter of Q104).

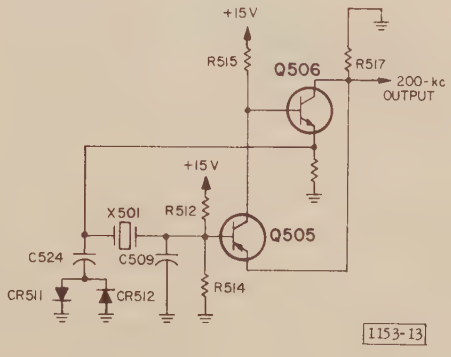


The input signal advances the state of the decade by one stage per pulse. A negative pulse is applied to the base of the advance driver, Q121, turning it off. Q102 loses base forward drive and goes off. The common-emitter voltage rises from +15 to +20 volts and Q101 goes on. The positive pulse at the common emitter is fed through C101, turning Q103 off and Q104 (the 1 driver) on. Each succeeding pulse applied to Q101 will advance the count by one digit. At the count of 10 the zero pair is switched to the initial conditions, and the negative pulse generated as the 9 lamp extinguished is fed from this ring counting unit as a carry pulse to the advance driver of the succeeding unit.

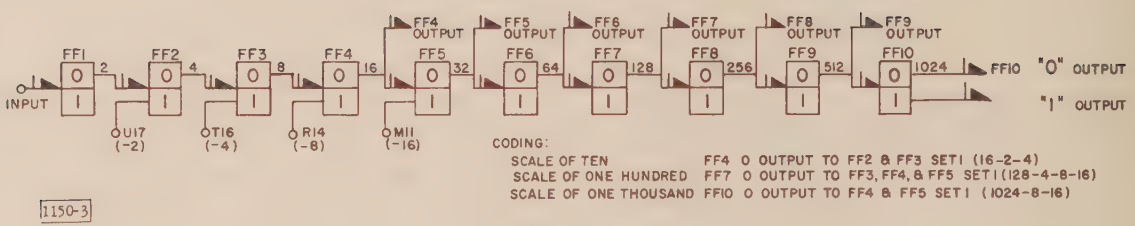
● 4.6 TIME-BASE OSCILLATOR

The time-base oscillator consists of Q505 and Q506 arranged as a modified Pierce crystal oscillator with an output frequency of 200 kc/s. Q505 and Q506 set the output impedance and provide 60 dB of negative feedback to achieve a circuit largely independent of transistor parameters and changes in voltage and temperature. A room-temperature, GT-cut crystal is used which, together with the large amount of negative feedback, results in an oscillator with a very stable frequency characteristic.

The output is fed through an amplifier, Q507, to a 2:1 scaler. The scaler consists of Q508 and Q509 connected as a multivibrator that divides, by 2, any input frequency over 150 kc/s. The scaler's 100-kc output is applied to the rear-mounted INT 100 kc output connector, to the time-base dividers in the FREQUENCY position of the MEASUREMENT switch, and to the time-base dividers and INPUT terminals in the 100 KC TEST position of the MEASUREMENT switch.



4.7 TIME-BASE DIVIDERS



There are two identical scale-of-1000 time-base dividers used in the Type 1153, the clock scaler and the program scaler. Each divider consists of 10 identical, serially connected flip-flips. The resolution of each scale-of-1000 divider permits counting up to 200 kc/s.

There is no internal coding in these dividers. In the absence of a set-1 signal on any of the second through fifth flip-flops, the system counts in a binary fashion (aggregation of $2^{10} = 1024$).

Outputs from the fourth through the tenth flip-flops connect to the COUNTING TIME and DISPLAY TIME switches. Inputs for feedback are provided for the second through the fifth flip-flops. Only a single feedback path is necessary to code the first scale-of-1000 divider (clock scaler), which produces the 100-cycle clock from the quartz-crystal oscillator.

The feedback coding for the clock scaler is permanently wired on the socket into which the scaler card plugs. The coding connects from the "1" output of the tenth flip-flop to the set-1 input of the fourth and fifth flip-flops. With this feedback connection, when the tenth flip-flop is triggered to the "1" state, the fourth flip-flop (which is in the "0" state) is set to 1, which subtracts 8 from the total, and the fifth flip-flop (which is also in the "0" state) is set to 1, which subtracts 16 from the total. Thus the feedback "converts" the binary 1024-to-1 divider to a 1000-to-1 divider (1024 - 8 - 16 = 1000).

The second scale-of-1000 divider (program scaler) provides the gate and display times. To provide accurate gate times, the program scaler can be used as a scale-of-10, scale-of-100, or scale-of-1000 divider. When used as a scale-of-10 divider, the output of the fourth flip-flop is connected through the COUNTING TIME switch to the program control and feedbacks are provided to the set-1 terminals of the second and third flip-flops (16 - 2 - 4 =10). When used as a scale-of-100 divider, the output of the seventh flip-flop is fed through the COUNTING TIME switch to the program control and feedbacks are provided to the set-1 terminals of the third, fourth, and fifth flip-flops (128 - 4 - 8 - 16=100). All 10 flip-flops are used for the scale-of-1000 divider. Feedback is provided from the tenth flip-flop to the set-1 terminals of the fourth and fifth flip-flops (1024 - 8 - 16 = 1000), as in the clock scaler.

● 4.8 PROGRAM CONTROL

Refer to the logic diagram on page 43.

Assume that the measurement switch is at FREQ, the COUNTING TIME switch at 0.1 SEC, and the DISPLAY TIME switch at 4 (for a 0.16-second display).

a. Assume that a reset pulse has just been produced; thus:

(1) Flip-flop (FF1) is in the 0 state, so gate 1 (G1) is closed,

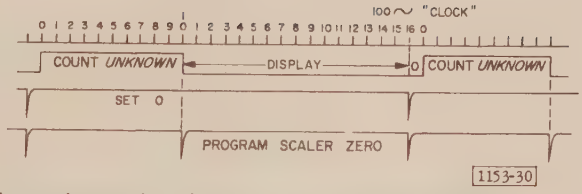
(2) FF2 is in the 0 state, so G3 and G5 are closed and G4 is open.

(3) The program scaler is set to 0.

b. The first 100-cycle clock pulse from the clock scaler passes through G2 and sets FF1 to 1, opening G1. The count begins and the program scaler is advanced from 0 to 1.

c. The third clock pulse advances the program scaler from 1 to 2, the fourth clock pulse advances the scaler from 2 to 3, etc.

d. At the count of 8 in the program scaler, feedback is sent through G4 for binary-to-decimal conversion.


100 ~ "CLOCK"
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 0
COUNT UNKNOWN
DISPLAY
0
COUNT UNKNOWN
SET 0
PROGRAM SCALER ZERO
1153-30

Timing diagram for a frequency (or check) measurement

e. The tenth pulse of the program scaler passes through the COUNTING TIME switch to set FF2 to 1, closing G2 and G4 opening G3 and G5 and generating a zero-set pulse for the program scaler through G6.

f. The next clock pulse passes through G3 and sets FF1 to 0, closing G1 and stopping the count. Note that the gate time has been 10 counts.

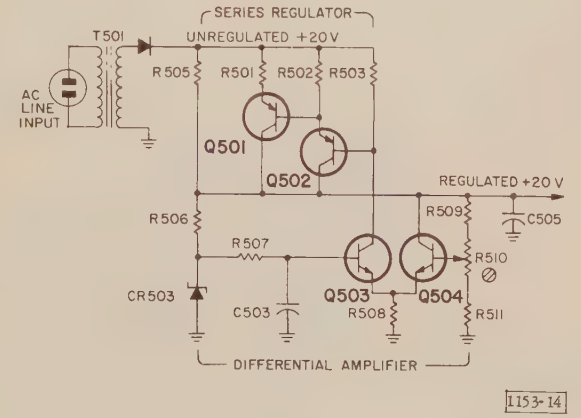
g. The next clock pulse advances the program scaler from 0 to 1, the following clock pulse advances the scaler from 1 to 2, etc; until the sixteenth clock pulse passes through the DISPLAY TIME switch and G5, generating the reset pulse.

h. The cycle repeats for the next measurement.

● 4.9 POWER SUPPLY

A single regulated dc source of +20 volts, with respect to chassis ground, is used for all circuits in the Type 1153 counters. A series-type electronic regulator is used for both dc voltage control and for ripple reduction. A portion of the output voltage (determined by the voltage divider, R509, R510, and R511) is compared with a fixed reference voltage (determined by Zener diode CR503) in a differential amplifier (Q503 and Q504). If the output voltage increases, the current in Q504 also increases, decreasing the current in Q503. In turn, Q503 reduces the base current in the emitter-follower (Q502) and in the series transistor (Q501), reducing the output voltage.

When power is first applied, base forward drive for Q503 is supplied via a 15-ohm resistor, R505, which will allow the regulator to start. In normal operation this resistor supplies a portion of the load current.



SECTION 5

SERVICE AND MAINTENANCE

CONTENTS

5.1 Warranty 24
5.2 Service 24
5.3 Routine Maintenance 25
5.4 General Troubleshooting 26
5.5 Program Troubleshooting 27
5.6 Calibration Procedure 28

Additional information, such as schematics, waveforms, dc voltages, and etched-board layouts, is contained in Section 6, Parts Lists and Schematics.

5.1 WARRANTY

We warrant that each new instrument sold by us is free from defects in material and workmanship, and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory, sales engineering office, or authorized repair agency personnel, will be repaired, or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

5.2 SERVICE

The two-year warranty stated above attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone our Service Department (see rear cover), giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial and type numbers of the instrument.

Before returning an instrument to General Radio for service, please write to our Service Department or nearest Sales Engineering office, requesting a "Returned Material Tag." Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

5.3 ROUTINE MAINTENANCE

5.3.1 GENERAL

Clean the air filter, oil the motor, and, in case of trouble, check the indicator lamps first.

The Type 1153 Series Digital Frequency Meters feature a modular construction that greatly simplifies repair. Transistors are on etched boards which, except for the program-control and power-supply boards, are easily removable from the main structure. To keep "down time" to a minimum, the user can replace a defective board immediately, thus keeping the counter in use while the defective board is being repaired. Components not mounted on etched boards include front-panel controls and switches, indicators, plugs, sockets, power-supply regulating transistor and rectifier diodes, and the power transformer.

5.3.2 AIR FILTER

To maintain proper cooling efficiency, the air filter should be cleaned periodically. Local air conditions determine how often this is necessary. To clean, release the air filter from its holder, rap gently to remove excess dirt, flush from the dirty side with hot soapy water, rinse, and let dry. Commercially available preparations to increase the filtering efficiency may be applied but are not necessary.

5.3.3 FAN MOTOR

For long, trouble-free operation, lubricate the fan motor at least once a year with SAE 20 or 30 premium-quality oil. There are two lubricating holes, one in each of the brass brackets on either side of the motor laminations.

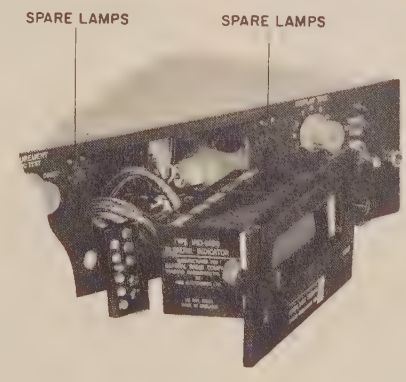
5.3.4 INDICATOR LAMPS

Most troubles can be traced to defective indicator lamps. To determine the lamp at fault, perform Check 4b, page 26.

Burned-out (open-circuited) lamps will cause the 220-kc and 40-kc Decimal Ring Counting Units to fail. To gain access to the lamps, turn off the power to avoid shorting the connecting terminals to the chassis, turn the two knurled panel screws on either side of the indicator bank a quarter turn counterclockwise, and pull the indicator bank from the instrument. Eight spare indicator bulbs are provided in the front panel and are accessible when the indicator bank is removed. To remove a burned-out bulb, remove the two screws at the rear of the faulty indicator.

The probability of failure for incandescent bulbs is a function of their operating time. Very few bulbs will have to be replaced until the instrument has accumulated several thousand hours of use, and then the rate of replacement will increase rapidly. We recommend that all bulbs be replaced when increase in failure rate is noted (typically after 5000 hours of use). You will notice that used bulbs have darkened due to condensation of filament material on the inside of the glass envelope and may not provide sufficient illumination if continued in use.

The lamps supplied in the Type 1153 counters are 14-V, 80-mA General Electric Type 330 or equivalent.



● 5.4 GENERAL TROUBLESHOOTING

These checks should localize 90% of all troubles to a small group of components. The checks are fast, simple, and performed without external test equipment or removal of the cabinet. More detailed checks are given on page 27 .

Preliminary measurement conditions:

IMPEDANCE . . . . . 100 kΩ
MEASUREMENT. . . . . COUNT
DISPLAY TIME 10
COUNTING TIME . . . . .01 SEC
COUNT/MULT INT . . . START

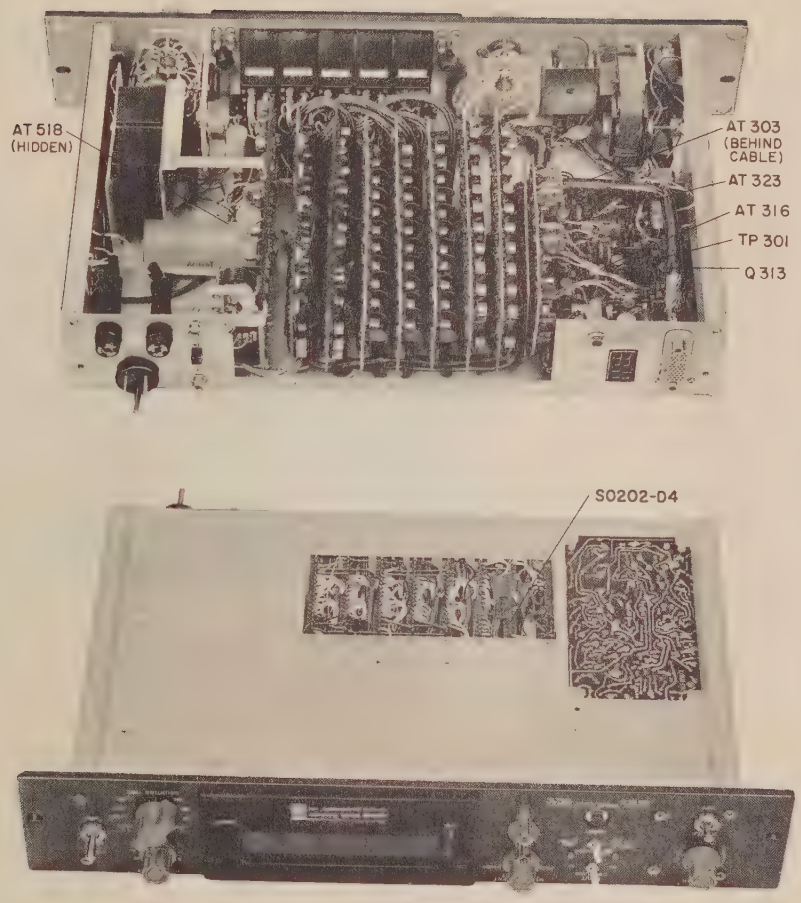
Check	*Procedure*	*Observation*
1	Connect to power line and turn POWER on.	**If blower starts** . . . . Power line and fuses ok. **If COUNT lamp glows** . . . . B+ present.
2	Momentarily push RESET button.	**If display is 00000** . . . . Set "0" (Q307 through Q310) ok, register cleared and counting units set to zero, zero lamps ok. **If display is at normal brilliance** . . . Regualted B+ (Q501 through Q504) ok.
3	Turn TRIGGER LEVEL back and forth 10 complete cycles.	**If display advances one count per cycle and final display is 00010** . . . . Input circuit (Q401 through Q409) ok, main gate (G1) open and passing pulses to be counted, 10-Mc counting unit and its indicators ok. If check fails, check waveforms and dc voltages of input circuit (page 53) and 10-Mc counting unit (page 55) .
4	a. Set MEASUREMENT to 100-kc TEST, DISPLAY TIME to 10, COUNTING TIME to .01 SEC.	**If display is 01000 and blinks every 10 seconds** . . . . Oscillator (Q505 through Q509) ok, 100-kc to 100-cycle counting units ok, and program control ok. If check fails, proceed to b.
	b. Set COUNTING TIME to 1 SEC.	**If instrument counts for one second then display 00000** . . . . Lamps ok. If one of the two right-hand indicators is blank, proceed to next step. If one of the three left-hand indicators is blank, check lamps in blank indicator for resistance to ground of 30 to 50 Ω; infinite resistance indicates lamp is burned out.
	Set MEASUREMENT to COUNT, set COUNT/MULT INT to START, and turn TRIGGER LEVEL back and forth several cycles.	**If display advances one count per cycle up to 00099** . . . . Lamps ok. If a number on one of the two right-hand indicators fails to light, the lamp for that number is burned out.
	c. Set MEASUREMENT to 100-kc TEST, COUNTING TIME to .01 SEC, DISPLAY TIME to 4.	**If display is 01000 and blinks every 0.16 second** . . . . Q201 through Q208 are ok.
	Set DISPLAY TIME to 5.	**If display is 01000 and blinks every 0.32 second** . . . . . Q209 and Q210 are ok.
	Set DISPLAY TIME to 6.	**If display is 01000 and blinks every 0.64 second** . . . . . Q211 and Q212 are ok.
	Set DISPLAY TIME to 7.	**If display is 01000 and blinks every 1.28 seconds** . . . . . Q213 and Q214 are ok.
	Set DISPLAY TIME to 8.	**If display is 01000 and blinks every 2.56 seconds** . . . . . Q215 and Q216 are ok.
	Set DISPLAY TIME to 9.	**If display is 01000 and blinks every 5.12 seconds** . . . . . Q217 and Q218 are ok.
	Set DISPLAY TIME to 10.	**If display is 01000 and blinks every 10.24 seconds** . . . . Q219 and Q220 are ok.
5	Set COUNTING TIME to 0.1 SEC and push RESET button.	Left-hand indicator should read 1.
	Set COUNTING TIME to 1 SEC and push RESET button.	Left-hand indicator should count to 9 and cycle to 0, then SPILL lamp should glow and instrument should stop counting. If SPILL lamp operates, Q319 and Q320 are ok. If instrument counts properly, all counting units are ok, G4 (Q316 through Q318) is ok, G6 (Q314 and Q315) is ok, and the program scaler is ok.
	Set COUNTING TIME to 10 SEC and push RESET button.	Left-hand indicator should count to 9 and cycle to 0, then SPILL lamp should glow and instrument should count to 9 and cycle to 0 nine more times (ten in all) before it stops. If the check fail, check waveforms and dc voltages of program control (page 47 and 49).

● 5.5 PROGRAM TROUBLESHOOTING

If a general troubleshooting check indicated a program failure, perform the following checks:

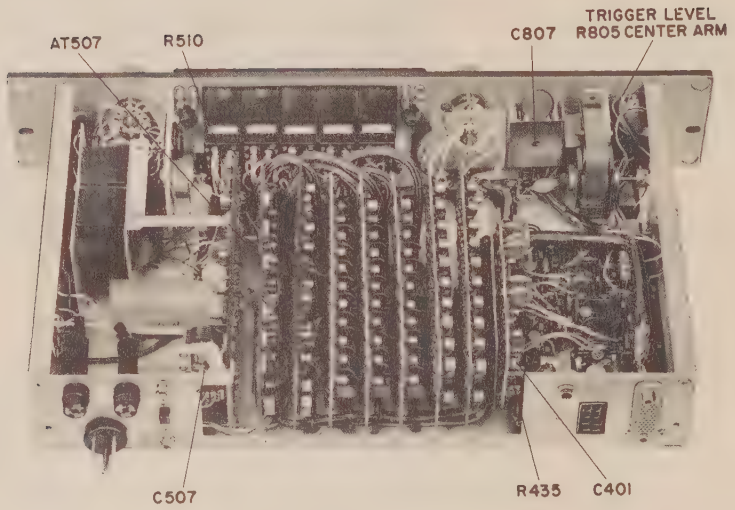
Preliminary measurement conditions:

TIME BASE (rear). . . . EXT
Cabinet removed.



Check	*Procedure*	*Observation*
A	Connect voltmeter to TP301, push RESET button, and note reading. Momentarily connect case of Q313 to AT316 and note reading.	**If voltmeter first reads +19V and then reads +5V (after Q313 case is momentarily connected to AT316)** . . . . FF2 (Q312 and Q313) ok.
B	Set MEASUREMENT to 100 kc TEST, connect voltmeter to AT323, push RESET button, and note reading. Momentarily ground AT303.	**If voltmeter first reads +17V and then reads +13.5V (after AT303 is momentarily grounded)** . . . . FF1 (Q303 and Q304) ok. **If COUNT lamp glows** . . . . COUNT lamp and Q305 are ok.
C	Set TIME BASE (rear) to INT connect voltmeter SO202-D4.	**If voltmeter reads +12.5V** . . . . 1000:1 time-base divider and oscillator (Q505 through Q509) are ok. If check fails, proceed to Check D.
D	Connect voltmeter to AT518.	**If voltmeter reads -10V** . . . . Oscillator (Q505 through Q509) is ok. (Check C failure due to 1000:1 time-base divider.) If check fails, proceed to Check E.
E	Set TIME BASE (rear) to EXT, apply 1-V p-to-p, 100-kc signal to EXT 100 kc INPUT connector (rear), and connect voltmeter to AT518.	**If voltmeter reads -10V** . . . . Oscillator amplifier (Q508 and Q509) is ok. (Check D failure due to Q505, Q506, or Q507.) If check fails, Q508 or Q509 is faulty.

5.6 CALIBRATION PROCEDURE



5.6.1 INTRODUCTION

Each step in the calibration procedure should be performed in sequence since one step serves as a foundation for the next. A complete calibration insures that all circuits are operating properly and within specifications. The Type 1153-A Digital Frequency Meter incorporates the high reliability one expects of conservatively designed, semiconductor circuits and routine calibrations are unnecessary.

5.6.2 EQUIPMENT REQUIRED

Dc Voltmeter

Range: 0 to 25 V, ±3% accuracy.
Impedance: At lease 20,000 ohms per volt.

Sinewave Oscillator
Frequency: 1 kc/s to 9.9 Mc/s
Output: 100 mV to 10 V, p-to-p.

Radio Receiver
Capable of receiving WWV on 5 Mc/s.

100-pF Capacitor

5.6.3 POWER SUPPLY

R510 Turn POWER on, connect a voltmeter to AT507 or the collector of Q501, and adjust R510 for +20 volts.

5.6.4 INPUT CIRCUIT

Set controls as follows:

TRIGGER LEVEL . . . . Centered
INPUT COUPLING . . . . AC
IMPEDANCE . . . . . 1 MΩ
MEASUREMENT . . . . FREQUENCY
DISPLAY TIME 4
COUNTING TIME . . . . 0.1 SEC

TRIGGER LEVEL mechanical zero: Connect a voltmeter to the center arm of the TRIGGER LEVEL potentiometer, R805, and set the potentiometer for -0.435 volt, Loosen the set screw in the knob and slip the knob on the shaft so that the white dot points straight up. Retighten the set screw.

R435 Sensitivity: Connect a 10-volt, p-to-p, 1-kc sinewave signal to the INPUT terminals; the display should read 001.00. Reduce the amplitude of the input signal to 1 volt, p-to-p, and adjust R435 for a display of 001.00.

C401 100-kΩ high-frequency adjustment: Set the COUNTING TIME switch to .01 SEC and the IMPEDANCE switch to 100 kΩ. Change the input signal to 100 millivolts, p-to-p, of 9.9 Mc/s and adjust C401 for a display of 9.9000.

C807 1-MΩ high-frequency adjustment: Set the IMPEDANCE switch to 1 MΩ. Change the input signal to 1 volt, p-to-p, of 9.9 Mc/s and adjust C807 for a display of 9.9000.

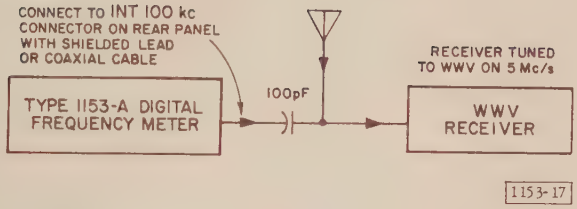
5.6.5 TIME-BASE OSCILLATOR

WWV is a convenient and accurate reference frequency with which to compare the oscillator frequency of the Type 1153. The two frequencies are mixed and the oscillator of the counter is adjusted for a zero beat.

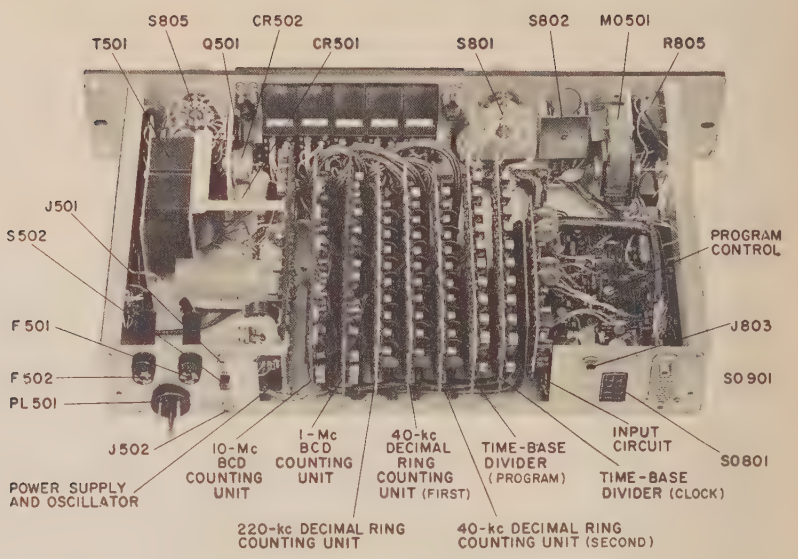
If the receiver has an "S" meter, the meter can be used as the zero-beat detector and the oscillator in the counter is adjusted for very slow excursions of the meter needle.

If the receiver has no "S" meter, the speaker can be used as the zero-beat detector. The receiver's beat-frequency oscillator is turned on and the oscillator in the counter is adjusted for a very low frequency audio tone.

Set the MEASUREMENT switch to COUNT. Connect a shielded lead or coaxial cable to the INT 100 kc output connector on the rear panel of the Type 1153 and connect it, via a 100-pF capacitor, to the antenna of the receiver. Tune the receiver to WWV on 5 Mc/s.

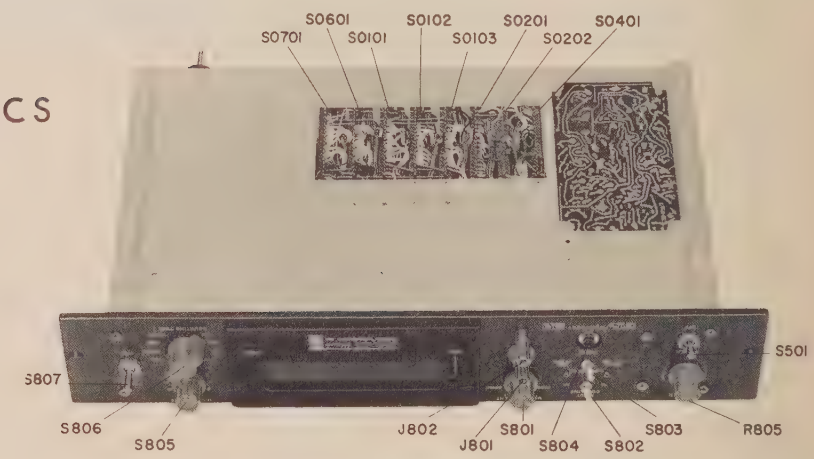

CONNECT TO INT 100 kc CONNECTOR ON REAR PANEL WITH SHIELDED LEAD OR COAXIAL CABLE
TYPE 1153-A DIGITAL FREQUENCY METER
100pF
RECEIVER TUNED TO WWV ON 5 Mc/s
WWV RECEIVER
1153-17

C507 Adjust C507 for a zero beat. A zero beat of less than 0.5 c/s indicates a precision of adjustment of better than 1 part in 10^7.



SECTION 6

PARTS LIST AND SCHEMATICS



● CONTENTS

			Page No.
Parts List			31-42
Schematics (Includes waveforms, dc voltages and etched-board layouts):			
	Etched-Circuit board Assembly Number	*Reference Number Series*	
Logic Diagram	—	—	43
Interconnections	—	800 and 900 to 950	44,45
Program Control	1153-2730	300	47,49
Input Circuit	1153-4740	400	51
10-Mc BCD Counting Unit	1153-4770	700	53,55
1-Mc BCD Counting Unit	1153-4760	600	57
220-kc Decimal Ring Counting Unit	1150-4000	100	59
40-kc Decimal Ring Counting Unit (2 used)	1150-4010	100	61
Time-Base Divider (2 used)	1151-4720	200	63
Power Supply and Oscillator	1153-2751	500	65
Type 1153-P1 Frequency Multiplier	1153-3100	960 up	67

PARTS LIST

REF NO.	DESCRIPTION	PART NO.
CAPACITORS		
C101 thru C110	*Ceramic, 0.001 µF ±10% 500V **Ceramic, 0.0022 µF +10% 500V	4406-2108 4406-2228
C111	*Ceramic, 0.001 µF ±10% 500V **Ceramic, 0.0033 µF ±10% 500V	4406-2108 4406-2338
C201 thru C220	Ceramic, 0.001 µF ±5% 500V	4405-2105
C221 thru C230	Ceramic, 330 pF ±10% 500V	4404-1338
C301	Ceramic, 220 pF ±5% 500V	4404-1225
C302	Ceramic, 68 pF ±5% 500V	4404-0685
C305	Ceramic, 0.1 µF +80-20% 50V	4403-4100
C306	Ceramic, 0.1 µF ±20% 25V	4400-2050
C307	Ceramic, 0.01 µF +80-20% 50V	4401-3100
C308	Ceramic, 0.01 µF +80-20% 500V	4406-3109
C309	Electrolytic, 100 µF +100-10% 15V	4450-2800
C312	Ceramic, 0.001 µF ±10% 500V	4405-2105
C313	Ceramic, 1 µF ±20% 25V	4400-2070
C314	Ceramic, 330 pF ±10% 500V	
C315	Ceramic, 330 pF ±10% 500V	
C316	Ceramic, 330 pF ±10% 500V	
C317	Ceramic, 0.001 µF ±10% 500V	4405-2105
C318	Ceramic, 0.001 µF ±10% 500V	4405-2105
C319	Ceramic, 0.47 µF ±20% 25V	4400-2054
C320	Ceramic, 0.001 µF ±10% 500V	4405-2105
C321	Ceramic, 0.01 µF +80-20% 500V	4406-3100
C322	Electrolytic, 100 µF +100-10% 15V	4450-2800
C323	Ceramic, 0.01 µF +80-20% 500V	4406-3109
C324	Ceramic, 0.1 µF ±20% 25V	4400-2050
C325	Ceramic, 0.022 µF +80-20% 500V	4407-3229
C326	Electrolytic, 100 µF +100-10% 15V	4450-2800
C327	Ceramic, 0.001 µF ±10% 500V	4405-2105
C328	Ceramic, 0.01 µF +80-20% 500V	4406-3109
C401	Variable, 8 to 50 pF	4910-1170
C402	Ceramic, 33 pF ±5% 500V	4404-0335
C403	Ceramic, 0.47 µF ±20% 25V	4400-2054
C404	Ceramic, 1 µF ±20% 25V	4400-2070
C405	Ceramic, 0.47 µF ±20% 25V	4400-2054
C406	Ceramic, 0.1 µF +80-20% 50V	4403-4100
C407	Ceramic, 62 pF ±10% 500V	4404-0628
C408	Ceramic, 0.1 µF +80-20% 12V	4403-4100
C409	Ceramic, 33 pF ±5% 500V	4404-0335
C410	Ceramic, 0.1 µF +80-20% 50V	4403-4100
C411	Ceramic, 0.1 µF +80-20% 12V	4403-4100
C412	Ceramic, 0.1 µF +80-20% 12V	4403-4100
C413	Ceramic, 330 pF ±5% 500V	4404-1335
C414	Ceramic, 330 pF ±5% 500V	4404-1335
C415	Ceramic, 330 pF ±10% 500V	4404-1338
C416	Ceramic, 0.1 µF +80-20% 50V	4403-4100
C417	Ceramic, 2.2 µF ±20% 25V	4400-2080

***Value for 220-kc Decimal Ring Counting Unit**
****Value for 40-kc Decimal Ring Counting Unit**

REF NO.	DESCRIPTION	PART NO.
C501	Electrolytic, 6.8 µF ±20% 35V	4450-5000
C502	Electrolytic, 2400 µF ±20% 35V	4450-5610
C503	Ceramic, 0.01 µF +80-20% 50V	4401-3100
C504	Ceramic, 0.01 µF +80-20% 50V	4401-3100
C505	Electrolytic, 6.8 µF ±20% 34V	4450-5000
C506	Mica, 0.001 µF ±2% 500V	4590-0690
C507	Variable air, 4 to 50 pF	4380-0300
C508	Ceramic, 47 pF ±5% 300V	4391-0475
C509	Mica, 0.001 µF ±2% 500V	4590-0690
C510	Ceramic, 0.1 µF +80-20% 50V	4403-4100
C511	Ceramic, 0.1 µF +80-20% 50V	4403-4100
C512	Ceramic, 0.1 µF +80-20% 50V	4403-4100
C513	Ceramic, 0.01 µF +80-20% 500V	4406-3109
C514	Ceramic, 0.1 µF ±10% 500V	4403-4100
C515	Ceramic, 0.1 µF ±10% 500V	4403-4100
C516	Ceramic, 0.1 µF +80-20% 50V	4403-4100
C517	Ceramic, 1 µF ±20% 25V	4400-2070
C518	Ceramic, 820 pF ±5% 500V	4405-1825
C519	Ceramic, 220 pF ±10% 500V	4404-1228
C520	Ceramic, 0.01 µF +80-20% 50V	4401-3100
C521	Ceramic, 470 pF ±10% 500V	4404-1478
C522	Ceramic, 0.1 µF +80-20% 50V	4403-4100
C523	Ceramic, 0.01 µF +80-20% 50V	4401-3100
C524	Ceramic, 0.1 µF +80-20% 50V	4403-4100
C525	Ceramic, 0.01 µF +80-20% 500V	4406-3109
C526	Ceramic, 0.0047 µF ±10% 500V	4407-2478
C601	Ceramic, 0.1 µF +80-20% 50V	4403-4100
C602	Ceramic, 150 pF ±5% 500V	4404-1155
C603	Ceramic, 150 pF ±5% 500V	4404-1155
C604	Ceramic, 0.01 µF +80-20% 50V	4401-3100
C605	Ceramic, 82 pF ±5% 500V	4404-0825
C606	Ceramic, 220 pF ±5% 500V	4404-1225
C607	Ceramic, 220 pF ±5% 500V	4404-1225
C608	Ceramic, 0.01 µF +80-20% 50V	4401-3100
C609	Ceramic, 0.01 µF +80-20% 50V	4401-3100
C610	Ceramic, 82 pF ±5% 500V	4404-0825
C611	Ceramic, 330 pF ±5% 500V	4404-1335
C612	Ceramic, 330 pF ±5% 500V	4404-1335
C613	Ceramic, 0.01µF +80-20% 50V	4401-3100
C614	Ceramic, 82 pF ±5% 500V	4404-0825
C615	Ceramic, 330 pF ±5% 500V	4404-1335
C616	Ceramic, 330 pF ±5% 500V	4404-1335
C617	Ceramic, 0.01 µF +80-20% 50V	4401-3100
C618	Ceramic, 0.001 µF ±10% 500V	4405-2108
C619	Ceramic, 220 pF ±10% 500V	4404-1228
C620	Ceramic, 330 pF ±5% 500V	4404-1335
C701	Ceramic, 0.1 µF ±80-20% 50V	4403-4100
C702	Ceramic, 47 pF ±5% 500V	4404-0475
C703	Ceramic, 47 pF ±5% 500V	4404-0475
C704	Ceramic, 0.01 µF +80-20% 50V	4401-3100
C705	Ceramic, 120 pF ±5% 500V	4404-1125
C706	Ceramic, 82 pF ±5% 500V	4404-0825
C707	Ceramic, 82 pF ±5% 500V	4404-0825
C708	Ceramic, 0.01 µF +80-20% 50V	4401-3100
C709	Ceramic, 0.01 µF +80-20% 50V	4401-3100
C710	Ceramic, 120 pF ±5% 500V	4404-1125
C711	Ceramic, 82 pF ±5% 500V	4404-0825
C712	Ceramic, 82 pF ±5% 500V	4404-0825

	REF NO.	DESCRIPTION	PART NO.
	C713	Ceramic, 0.01 µF +80-20% 50V	4401-3100
	C714	Ceramic, 120 pF ±5% 500V	4404-1125
	C715	Ceramic, 150 pF ±5% 500V	4404-1155
	C716	Ceramic, 150 pF ±5% 500V	4404-1155
	C717	Ceramic, 0.01 µF +80-20% 50V	4401-3100
	C718	Ceramic, 0.001 µF ±10% 500V	4405-2108
	C719	Ceramic, 0.001 µF ±10% 500V	4405-2108
	C720	Ceramic, 120 pF ±5% 500V	4404-1125
	C721	Ceramic, 0.01 µF +80-20% 50V	4401-3100
	C722	Ceramic, 0.01 µF +80-20% 50V	4401-3100
	C801	Electrolytic, 33 µF ±20% 20V	4450-5613
	C802	Ceramic, 0.1 µF +80-20% 50V	4403-4100
	C803	Ceramic, 0.1 µF +80-20% 50V	4403-4100
	C804	Ceramic, 0.01 µF ±20% 500V	4406-3100
	C805	Ceramic, 0.001 µF ±10% 500V	4405-2108
	C806	Ceramic, 0.047 µF +80-20% 500V	4409-3479
	C807	Variable, 1.5 to 7 pF	4910-0300
	C808	Ceramic, 47 pF ±5% 500V	4404-0475
	C809	Ceramic, 0.1 µF +80-20% 50V	4403-4100
	C810	Electrolytic, 10 µF ±20% 20V	4450-5100
DIODES	CR101	Type 1N118A	6082-1006
	CR102 thru CR111	Type 1N645	6082-1016
	CR201 thru CR224	Type 1N625	6082-1012
	CR301	Type 1N625	6082-1012
	CR302	Type 1N625	6082-1012
	CR303	Type 1N645	6082-1016
	CR304	Type 1N645	6082-1016
	CR305	Type 1N645	6082-1016
	CR306	Type 1N625	6082-1012
	CR307	Type 1N455	6082-1010
	CR308	Type 1N645	6082-1016
	CR309	Type 1N645	6082-1016
	CR310	Type 1N645	6082-1016
	CR311 thru CR316	Type 1N625	6082-1012
	CR317 thru CR320	Type 1N645	6082-1016
	CR321	Type 1N625	6082-1012
	CR322	Type 1N625	6082-1012
	CR401	Type TD-1	6085-1003
	CR402	Type 1N965B	6083-1015
	CR404	Type 1N645	6082-1016
	CR405	Type 1N645	6082-1016
	CR407	Type 1N958B	6083-1057
	CR408	Type 1N746	6083-1005
	CR409	Type 1N957B	6083-1009
	CR410	Type 1N3604	6082-1001
	CR501	Type 1N3493	6081-1007
	CR502	Type 1N3493	6081-1007
	CR503	Type 1N941	6083-1013

	REF NO.	DESCRIPTION	PART NO.
	CR504	Type 1N645	6082-1016
	CR505	Type 1N645	6082-1016
	CR506	Type 1N625	6082-1012
	CR507	Type 1N625	6082-1012
	CR508	Type 1N625	6082-1012
	CR509	Type 1N645	6082-1016
	CR510	Type 1N645	6082-1016
	CR511	Type 1N625	6082-1012
	CR512	Type 1N625	6082-1012
	CR513	Type 1N629	6083-1015
	CR601 thru CR612	Type 1N118A	6082-1006
	CR613 thru CR622	Type 1N3604	6082-1001
	CR623	Type 1N3828A	6083-1056
	CR701 thru CR712	Type 1N995	6082-1002
	CR713 thru CR723	Type 1N3604	6082-1001
	CR726	Type 1N3828A	6083-1056
	CR801	Type 1N645	6082-1016
FUSES	F501	For 115-V operation, 1A 3AG slo-blo For 230-V operation, 0.5A 3AG slo-blo	5330-1400 5330-1000
	F502	For 115-V operation, 1A 3AG slo-blo For 230-V operation, 0.5A 3AG slo-blo	5330-1400 5330-1000
INDICATORS	I1 thru I6	Type IND-300 Indicator Assemblies, incandescent-lamp operated, each includes 10 lamps	5437-0300
	lamps	No. 330, 14V, 80 mA, size T-1 3/4	5600-0309
	spare lamps	Eight spare lamps are included with the instrument, see page	
JACKS	J501	Phono jack, Switchcraft No. 3505F INT 100 kc	4260-1280
	J502	Phono jack, Switchcraft No. 3505F EXT 100 kc INPUT	4260-1280
	J801	Binding-post assembly, consists of: INPUT One binding post, metal top Two insulators, gray plastic	4060-0100 4130-0200
	J802	Binding-post assembly, consists of: ground One binding post, metal top One spacer, metal	4060-0100 7800-0600
	J803	Telephone jack, Switchcraft No.12B PHOTOELECTRIC PICKOFF	4260-1200
INDUCTORS	L301	2.2 μH ±10%	4300-1200
	L302	2.2 μH ±10%	4300-1200
	L702	5.6 μH ±10%	4300-1800
	L703	4.7 μH ±10%	4300-1600
	L704	5.6 μH ±10%	4300-1800
	L706	5.6 μH ±10%	4300-1800
	L707	4.7 μH ±10%	4300-1600

	REF NO.	DESCRIPTION	PART NO.
	L708	5.6 μH ±10%	4300-1800
	L801	10,000 μH ±10%	4300-6200
MOTOR	MO501	Blower motor	5760-1200
		Fan blade	5180-4251
LAMPS	For lamps used in indicators, see INDICATORS, page		
	P801	Number 344, 10V,15MA, size T-1 3/4 SPILL	5600-0314
	P802	COUNT	5600-0314
	P803 thru P806	Number 330, 14V, 80 mA, size T-1 3/4 decimal points	5600-0309
PLUG	PL501	3-terminal power plug, consists of:	
		2-terminal power plug	4240-0600
		Ground pin	4240-0800
TRANSISTORS	Q101 thru Q120	Type 2N1303	8210-1019
	Q121	*Type MM-487	8210-1028
		**Type 2N1302	8210-1018
	Q201 thru Q220	Type 2N1303	8210-1019
	Q301	Type 2N1499B	8210-1068
	Q302	Type 2N1499B	8210-1068
	Q303	Type 2N779A	8210-7791
	Q304	Type 2N779A	8210-7791
	Q305	Type 2N1131	8210-1025
	Q306	Type 2N1303	8210-1019
	Q307	Type 2N1303	8210-1019
	Q308	Type 2N1302	8210-1018
	Q309	Type TI412	8210-1102
	Q310	Type 2N2714	8210-1047
	Q311	Type 2N1303	8210-1019
	Q312	Type 2N1303	8210-1019
	Q313	Type 2N1303	8210-1019
	Q314	Type 2N1302	8210-1018
	Q315 thru Q319	Type 2N1303	8210-1019
	Q320	Type 2N1302	8210-1018
	Q401	Type 2N708	8210-3089
	Q403	Type 4JX 12G1162	8210-1101
	Q404	Type 2N708	8210-3089
	Q405 thru Q410	Type 2N779A	8210-7791
	Q501	Type 2N1544	8210-1014
	Q502	Type 2N1131	8210-1025
	Q503	Type 2N1304	8210-1304
	Q504	Type 2N1304	8210-1304
	Q505	Type 2N779A	8210-7791
	Q506	Type 2N708	8210-3089
	Q507	Type 2N1305	8210-1305

***Value for 220-kc Decimal Ring Counting Unit**
****Value for 40-kc Decimal Ring Counting Unit**

	REF NO.	DESCRIPTION	PART NO.
	Q508	Type 2N1305	8210-1305
	Q509	Type 2N1305	8210-1305
	Q601 thru Q612	Type 2N3638	8210-1096
	Q613 thru Q620	Type 2N1499A	8210-1499
	Q621	Type 2N3638	8210-1096
	Q622	Type 2N3638	8210-1096
	Q701 thru Q710	Type 2N1305	8210-1305
	Q711	Type 2N1374	8210-1374
	Q712	Type 2N1305	8210-1305
	Q713	Type 2N976	8210-1057
	Q714	Type 2N976	8210-1057
	Q715 thru Q720	Type 2N779A	8210-7791
	Q721	Type 2N1305	8210-1305
	Q722	Type 2N1305	8210-1305
RESISTORS	R101	Composition, 68Ω ±5% 1/2w	6100-0685
	R102	Composition, 4.3 kΩ ±5% 1/2w	6100-2435
	R103	*Composition, 2.7 kΩ ±5% 1/2w	6100-2275
	R103	**Composition, 3.3 kΩ ±5% 1/2w	6100-2335
	R104	Composition, 68 Ω ±5% 1/2w	6100-0685
	R105	Composition, 4.3 kΩ ±5% 1/2w	6100-2435
	R106	*Composition, 2.7 kΩ ±5% 1/2w	6100-2275
	R106	**Composition, 3.3 kΩ ±5% 1/2w	6100-2335
	R107	Composition, 68 Ω ±5% 1/2w	6100-0685
	R108	Composition, 4.3 kΩ ±5% 1/2w	6100-2435
	R109	*Composition, 2.7 kΩ ±5% 1/2w	6100-2275
	R109	**Composition, 3.3 kΩ ±5% 1/2w	6100-2335
	R110	Composition, 68 Ω ±5% 1/2w	6100-0685
	R111	Composition, 4.3 kΩ ±5% 1/2w	6100-2435
	R112	*Composition, 2.7 kΩ ±5% 1/2w	6100-2275
	R112	**Composition, 3.3 kΩ ±5% 1/2w	6100-2335
	R113	Composition, 68 Ω ±5% 1/2w	6100-0685
	R114	Composition, 4.3 kΩ ±5% 1/2w	6100-2435
	R115	*Composition, 2.7 kΩ ±5% 1/2w	6100-2275
	R115	**Composition, 3.3 kΩ ±5% 1/2w	6100-2335
	R116	Composition, 68 Ω ±5% 1/2w	6100-0685
	R117	Composition, 4.3 kΩ ±5% 1/2w	6100-2435
	R118	*Composition, 2.7 kΩ ±5% 1/2w	6100-2275
	R118	**Composition, 3.3 kΩ ±5% 1/2w	6100-2335
	R119	Composition, 68 Ω ±5% 1/2w	6100-0685
	R120	Composition, 4.3 kΩ ±5% 1/2w	6100-2435
	R121	*Composition, 2.7 kΩ ±5% 1/2w	6100-2275
	R121	**Composition, 3.3 kΩ ±5% 1/2w	6100-2335
	R122	Composition, 68 Ω ±5% 1/2w	6100-0685
	R123	Composition, 4.3 kΩ ±5% 1/2w	6100-2435
	R124	*Composition, 2.7 kΩ ±5% 1/2w	6100-2275
	R124	**Composition, 3.3 kΩ ±5% 1/2w	6100-2335
	R125	Composition, 68 Ω ±5% 1/2w	6100-0685
	R126	Composition, 4.3 kΩ ±5% 1/2w	6100-2435
	R127	*Composition, 2.7 kΩ ±5% 1/2w	6100-2275

*Value for 220-kc Decimal Ring Counting Unit

**Value for 40-kc Decimal Ring Counting Unit

REF NO.	DESCRIPTION	PART NO.
R127	**Composition, 3.3 kΩ ±5% 1/2w	6100-2335
R128	Composition, 82 Ω ±5% 1/2w	6100-0825
R129	Composition, 4.3 kΩ ±5% 1/2w	6100-2435
R130	*Composition, 2.7 kΩ ±5% 1/2w	6100-2275
R130	**Composition, 3.3 kΩ ±5% 1/2w	6100-2335
R131	Composition, 5.1 kΩ ±5% 1/2w	6100-2515
R132	Composition, 560 Ω ±10% 1w	6110-1569
R133 thru R142	Composition, 330 Ω ±10% 1/2w	6099-1339
R201	Composition, 2.7 kΩ ±10% 1/4w	6099-2279
R202	Composition, 6.8 kΩ ±10% 1/4w	6099-2689
R203	Composition, 2.7 kΩ ±10% 1/4w	6099-2279
R204	Composition, 6.8 kΩ ±10% 1/4w	6099-2689
R205	Composition, 2.7 kΩ ±10% 1/4w	6099-2279
R206	Composition, 6.8 kΩ ±10% 1/4w	6099-2689
R207	Composition, 2.7 kΩ ±10% 1/4w	6099-2279
R208	Composition, 6.8 kΩ ±10% 1/4w	6099-2689
R209	Composition, 2.7 kΩ ±10% 1/4w	6099-2279
R210	Composition, 6.8 kΩ ±10% 1/4w	6099-2689
R211	Composition, 2.7 kΩ ±10% 1/4w	6099-2279
R212	Composition, 6.8 kΩ ±10% 1/4w	6099-2689
R213	Composition, 2.7 kΩ ±10% 1/4w	6099-2279
R214	Composition, 6.8 kΩ ±10% 1/4w	6099-2689
R215	Composition, 2.7 kΩ ±10% 1/4 w	6099-2279
R216	Composition, 6.8 kΩ ±10% 1/4w	6099-2689
R217	Composition, 2.7 kΩ ±10% 1/4w	6099-2279
R218	Composition, 6.8 kΩ ±10% 1/4w	6099-2689
R219	Composition, 2.7 kΩ ±10% 1/4w	6099-2279
R220	Composition, 6.8 kΩ ±10% 1/4w	6099-2689
R221	Composition, 2.7 kΩ ±10% 1/4w	6099-2279
R222	Composition, 6.8 kΩ ±10% 1/4w	6099-2689
R223	Composition, 2.7 kΩ ±10% 1/4w	6099-2279
R224	Composition, 6.8 kΩ ±10% 1/4w	6099-2689
R225	Composition, 2.7 kΩ ±10% 1/4w	6099-2279
R226	Composition, 6.8 kΩ ±10% 1/4w	6099-2689
R227	Composition, 2.7 kΩ ±10% 1/4w	6099-2279
R228	Composition, 6.8 kΩ ±10% 1/4w	6099-2689
R229	Composition, 2.7 kΩ ±10% 1/4w	6099-2279
R230	Composition, 6.8 kΩ ±10% 1/4w	6099-2689
R231	Composition, 2.7 kΩ ±10% 1/4w	6099-2279
R232	Composition, 6.8 kΩ ±10% 1/4w	6099-2689
R233	Composition, 2.7 kΩ ±10% 1/4w	6099-2279
R234	Composition, 6.8 kΩ ±10% 1/4w	6099-2689
R235	Composition, 2.7 kΩ ±10% 1/4w	6099-2279
R236	Composition, 6.8 kΩ ±10% 1/4w	6099-2689
R237	Composition, 2.7 kΩ ±10% 1/4w	6099-2279
R238	Composition, 6.8 kΩ ±10% 1/4w	6099-2689
R239	Composition, 2.7 kΩ ±10% 1/4w	6099-2279
R240	Composition, 6.8 kΩ ±10% 1/4w	6099-2689
R241 thru R270	Composition, 2.7 kΩ ±10% 1/4w	6099-2279
R271 thru R280A	Composition, 100 Ω ±10% 1/4w	6099-1109
R281	Composition, 220 Ω ±10% 1/4w	6099-1229

***Value for 220-kc Decimal Ring Counting Unit**
****Value for 40-kc Decimal Ring Counting Unit**

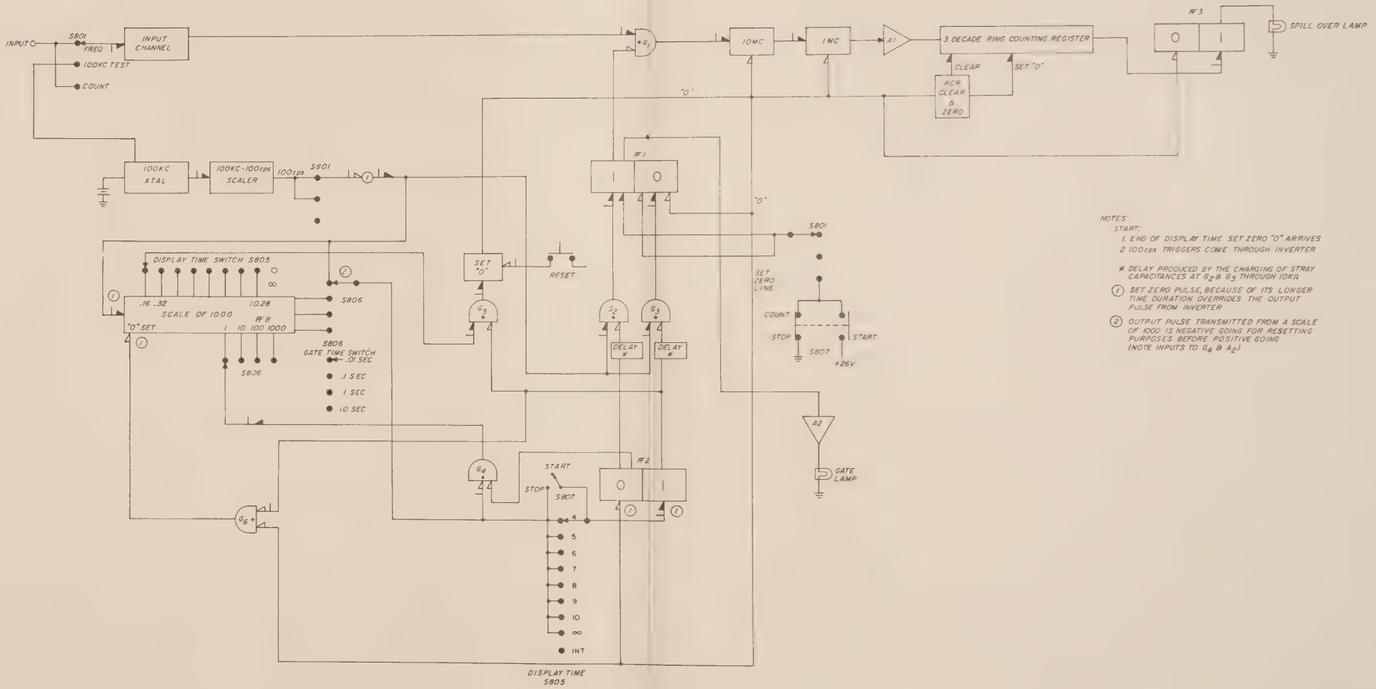
REF NO.	DESCRIPTION	PART NO.
R282	Composition, 220 Ω ±10% 1/4w	6099-1229
R283	Composition, 220 Ω ±10% 1/4w	6099-1229
R284	Composition, 220 Ω ±10% 1/4w	6099-1229
R302	Composition, 13 kΩ ±5% 1/4w	6099-3135
R303	Composition, 1.5 kΩ ±5% 1/2w	6100-2155
R304	Composition, 6.8 kΩ ±5% 1/4w	6099-2685
R305	Composition, 82 Ω ±5% 1/4w	6099-0825
R306	Composition, 10 kΩ ±5% 1/4w	6099-3105
R307	Composition, 1 kΩ ±5% 1/2w	6100-2105
R308	Composition, 560 Ω ±5% 1/2w	6100-1565
R309	Composition, 300 Ω ±5% 1/4w	6099-1305
R310	Composition, 300 Ω ±5% 1/4w	6099-1305
R311	Composition, 2.7 kΩ ±5% 1/4w	6099-2275
R312	Composition, 3.9 kΩ ±5% 1/4w	6099-2395
R313	Composition, 2.7 kΩ ±5% 1/4w	6099-2275
R314	Composition, 1 kΩ ±5% 1/4w	6099-2105
R315	Composition, 4.7 kΩ ±5% 1/4w	6099-2475
R316	Composition, 4.7 kΩ ±5% 1/4w	6099-2475
R317	Composition, 2.7 kΩ ±5% 1/4w	6099-2275
R318	Composition, 2.7 kΩ ±5% 1/4w	6099-2275
R319	Composition, 22 kΩ ±5% 1/4w	6099-3225
R320	Composition, 750 Ω ±5% 1/4w	6099-1755
R321	Composition, 22 kΩ ±5% 1/4w	6099-3225
R323	Composition, 2.7 kΩ ±5% 1/4w	6099-2275
R325	Composition, 10 kΩ ±5% 1/4w	6099-3105
R326	Composition, 47 kΩ ±5% 1/4w	6099-3275
R327	Composition, 2.7 kΩ ±5% 1/4w	6099-2275
R328	Composition, 4.7 kΩ ±5% 1/4w	6099-2475
R329	Composition, 560 kΩ ±5% 1/4w	6099-4565
R330	Composition, 3.3 kΩ ±5% 1/4w	6099-2335
R331	Composition, 15 kΩ ±5% 1/4w	6099-3155
R332	Composition, 2.7 kΩ ±5% 1/4w	6099-2275
R333	Composition, 200 Ω ±5% 1/4w	6099-1205
R334	Composition, 510 Ω ±5% 1/4w	6099-1515
R335	Composition, 1.3 kΩ ±5% 1/4w	6099-2135
R336	Composition, 5.6 kΩ ±5% 1/4w	6099-2565
R337	Composition, 3 kΩ ±5% 1/4w	6099-2305
R338	Composition, 2 kΩ ±5% 1/4w	6099-2205
R339	Composition, 7.5 kΩ ±5% 1/4w	6099-2755
R340	Composition, 10 kΩ ±5% 1/4w	6099-3105
R341	Composition, 12 kΩ ±5% 1/4w	6099-3125
R342	Composition, 2.7 kΩ ±5% 1/4w	6099-2275
R343	Composition, 2.7 kΩ ±5% 1/4w	6099-2275
R344	Composition, 10 kΩ ±5% 1/4w	6099-3105
R345	Composition, 10 kΩ ±5% 1/4w	6099-3105
R346	Composition, 10 kΩ ±5% 1/4w	6099-3105
R347	Composition, 4.7 kΩ ±5% 1/4w	6099-2475
R348	Composition, 4.7 kΩ ±5% 1/4w	6099-2475
R349	Composition, 8.2 kΩ ±5% 1/4w	6099-2825
R350	Composition, 68 kΩ ±5% 1/4w	6099-3685
R351	Composition, 2.7 kΩ ±5% 1/4w	6099-2275
R352	Composition, 4.7 kΩ ±5% 1/4w	6099-2475
R353	Composition, 4.7 kΩ ±5% 1/4w	6099-2475
R354	Composition, 2.7 kΩ ±5% 1/4w	6099-2275
R355	Composition, 1 kΩ ±5% 1/4w	6099-2105
R356	Composition, 510 Ω ±5% 1/4w	6099-1515
R357	Composition, 10 kΩ ±5% 1/4w	6099-3105
R358	Composition, 120 Ω ±5% 2w	6120-1125

REF NO.	DESCRIPTION	PART NO.
R359	Composition, 4.7 kΩ ±5% 1/4w	6099-2475
R360	Composition, 2.7 kΩ ±5% 1/4w	6099-2275
R361	Composition, 4.7 kΩ ±5% 1/4w	6099-2475
R362	Composition, 4.7 kΩ ±5% 1/4w	6099-2475
R363	Composition, 820 Ω ±5% 1/4w	6099-1825
R364	Composition, 10 kΩ ±5% 1/4w	6099-3105
R365	Composition, 6.8 kΩ ±5% 1/4w	6099-2685
R366	Composition, 680 Ω ±5% 1/4w	6099-1685
R367	Composition, 2 kΩ ±5% 1/4w	6099-2205
R368	Composition, 620 Ω ±5% 1/4w	6099-1625
R369	Composition, 10 kΩ ±5% 1/4w	6099-3105
R370	Composition, 360 Ω ±5% 1w	6110-1365
R371	Composition, 10 kΩ ±5% 1/4w	6099-3105
R372	Composition, 10 kΩ ±5% 1/4w	6099-3105
R373	Composition, 5.1 kΩ ±5% 1/4w	6099-2515
R374	Composition, 2.4 kΩ ±5% 1/4w	6099-2245
R375	Composition, 10 kΩ ±5% 1/4w	6099-3105
R376	Composition, 2 kΩ ±5% 1/4w	6099-2205
R401	Composition, 75 kΩ ±5% 1/4w	6099-3755
R402	Composition, 39 kΩ ±5% 1/4w	6099-3395
R403	Composition, 620 kΩ ±5% 1/4w	6099-4625
R404	Composition, 47 Ω ±5% 1/4w	6099-0475
R405	Composition, 47 Ω ±5% 1/4w	6099-0475
R406	Composition, 3.9 kΩ ±5% 1/4w	6099-2395
R407	Composition, 47 Ω ±5% 1/4w	6099-0475
R408	Composition, 47 Ω ±5% 1/4w	6099-0475
R409	Composition, 5.6 kΩ ±5% 1/4w	6099-2565
R410	Composition, 560 Ω ±5% 1/4w	6099-1565
R411	Composition, 5.6 kΩ ±5% 1/4w	6099-2565
R412	Composition, 39 kΩ ±5% 1/4w	6099-3395
R413	Composition, 18 kΩ ±5% 1/4w	6099-3185
R414	Composition, 5.6 kΩ ±5% 1/4w	6099-2565
R415	Composition, 1 kΩ ±5% 1/4w	6099-2105
R416	Composition, 20 kΩ ±5% 1/4w	6099-3205
R417	Composition, 2.7 kΩ ±5% 1/4w	6099-2275
R418	Composition, 2.2 kΩ ±5% 1/4w	6099-2225
R419	Composition, 560 Ω ±5% 1/4w	6099-1565
R420	Composition, 56 Ω ±5% 1/4w	6099-0565
R421	Composition, 560 Ω ±5% 1/4w	6099-1565
R422	Composition, 560 Ω ±5% 1/4w	6099-1565
R423	Composition, 3.9 kΩ ±5% 1/4w	6099-2395
R424	Composition, 820 Ω ±5% 1/4w	6099-1825
R425	Composition, 1.2 kΩ ±5% 1/4w	6099-2125
R426	Composition, 100 Ω ±5% 1/4w	6099-1105
R427	Composition, 390 Ω ±5% 1/4w	6099-1395
R428	Composition, 2.7 kΩ ±5% 1/4w	6099-2275
R429	Composition, 360 Ω ±5% 1/4w	6099-1365
R430	Composition, 200 Ω ±5% 1w	6110-1205
R431	Composition, 150 Ω ±5% 1/4w	6099-1155
R432	Composition, 220 Ω ±5% 1/4w	6099-1225
R433	Composition, 820 Ω ±5% 1/4w	6099-1825
R434	Composition, 330 Ω ±5% 1/4w	6099-1335
R435	Potentiometer, composition, 1 MΩ ±20%	6040-1500
R436	Composition, 2.2 kΩ ±5% 1/4w	6099-2225
R501	Wire-wound, 0.47 Ω ±10% 2w	6760-8479
R502	Composition, 200 Ω ±5% 1/2w	6100-1205
R503	Composition, 1 kΩ ±5% 1/2w	6100-2105
R504	Thyrector diode, 90 V	6741-1002

REF NO.	DESCRIPTION	PART NO.
R505	Wire-wound, 15 Ω ±5% 30w	6630-0155
R506	Composition, 1.2 kΩ ±5% 1/2w	6100-2125
R507	Composition, 1 kΩ ±5% 1/2w	6100-2105
R508	Composition, 3.9 kΩ ±5% 1/2w	6100-2395
R509	Precision wire-wound, 1 kΩ ±1% 3/10w	6730-1100
R510	Potentiometer, wire-wound 2 kΩ ±10%	6057-2209
R511	Precision wire-wound, 1.5 kΩ ±1% 3/10w	6730-2150
R512	Composition, 2.7 kΩ ±5% 1/2w	6100-2275
R513	Composition, 3.3 kΩ ±5% 1/2w	6100-2335
R514	Composition, 7.5 kΩ ±5% 1/2w	6100-2755
R515	Composition, 24 kΩ ±5% 1/2w	6100-3245
R516	Composition, 2.2 kΩ ±5% 1/2w	6100-2225
R517	Composition, 3.3 kΩ ±5% 1/2w	6100-2335
R518	Composition, 24 kΩ ±5% 1/2w	6100-3245
R519	Composition, 1 kΩ ±5% 1/2w	6100-2105
R520	Composition, 24 kΩ ±5% 1/2w	6100-3245
R521	Composition, 10 kΩ ±5% 1/2w	6100-3105
R522	Composition, 1 kΩ ±5% 1/2w	6100-2105
R523	Composition, 30 Ω ±5% 1/2w	6100-0305
R524	Composition, 2 kΩ ±5% 1/2w	6100-2205
R525	Composition, 3.9 kΩ ±5% 1/2w	6100-2395
R526	Composition, 820 Ω ±5% 1/2w	6100-1825
R527	Composition, 13 kΩ ±5% 1/2w	6100-3135
R528	Composition, 150 Ω ±5% 1/2w	6100-1155
R529	Composition, 470 Ω ±5% 1/2w	6100-1475
R530	Composition, 9.1 kΩ ±5% 1/2w	6100-2915
R531	Composition, 330 Ω ±5% 1w	6110-1335
R532	Composition, 2 kΩ ±5% 1/2w	6100-2205
R533	Composition, 2 kΩ ±5% 1/2w	6100-2205
R534	Composition, 470 Ω ±5% 1/2w	6100-1475
R601 thru R606	Composition, 4.7 kΩ ±5% 1/4w	6099-2475
R607	Composition, 68 Ω ±5% 2w	6120-0685
R608	Composition, 4.7 kΩ ±5% 1/4w	6099-2475
R609 thru R618	Composition, 390 Ω ±5% 1/4w	6099-1395
R619	Composition, 43 Ω ±5% 1w	6110-0435
R620	Composition, 5.1 kΩ ±5% 1/4w	6099-2515
R621	Composition, 1 kΩ ±5% 1/4w	6099-1105
R622	Composition, 5.1 kΩ ±5% 1/4w	6099-2515
R623	Composition, 1 kΩ ±5% 1/4w	6099-1105
R624	Composition, 510 Ω ±5% 1/4w	6099-1515
R625	Composition, 150 Ω ±5% 2w	6120-1155
R626	Composition, 390 Ω ±5% 1/4w	6099-1395
R627	Composition, 560 Ω ±5% 1/4w	6099-1565
R628	Composition, 3.3 kΩ ±5% 1/4w	6099-2335
R629	Composition, 3.3 kΩ ±5% 1/4w	6099-2335
R630	Composition, 560 Ω ±5% 1/4w	6099-1565
R631	Composition, 390 Ω ±5% 1/4w	6099-1395
R632 thru R635	Composition, 560 Ω ±5% 1/4w	6099-1565
R636	Composition, 4.7 kΩ ±5% 1/4w	6099-2475
R637	Composition, 560 kΩ ±5% 1/4w	6099-1565
R638	Composition, 560 kΩ ±5% 1/4w	6099-1565

REF NO.	DESCRIPTION		PART NO.
R639 thru R644	Composition, 3.3 kΩ ±5% 1/4w		6099-2335
R645 thru R648	Composition, 820 Ω ±5% 1/4w		6099-1825
R649 thru R656	Composition, 6.2 kΩ ±5% 1/4w		6099-2625
R701 thru R706	Composition, 4.7 kΩ ±5% 1/4w		6099-2475
R707	Composition, 1.5 kΩ ±5% 1/4w		6099-2155
R708	Composition, 4.7 kΩ ±5% 1/4w		6099-2475
R709 thru R718	Composition, 390 Ω ±5% 1/4w		6099-1395
R719	Composition, 27 Ω ±5% 1w		6110-0275
R720	Composition, 5.1 kΩ ±5% 1/4w		6099-2515
R721	Composition, 1 kΩ ±5% 1/4w		6099-2105
R722	Composition, 5.1 kΩ ±5% 1/4w		6099-2515
R723	Composition, 1 kΩ ±5% 1/4w		6099-2105
R724	Composition, 510 Ω ±5% 1/4w		6099-1515
R725	Composition, 120 Ω ±5% 2w		6120-1125
R726	Composition, 390 Ω ±5% 1/4w		6099-1395
R727	Composition, 300 Ω ±5% 1/4w		6099-1305
R728	Composition, 2.2 kΩ ±5% 1/4w		6099-2225
R729	Composition, 2.2 kΩ ±5% 1/4w		6099-2225
R730 thru R735	Composition, 300 Ω ±5% 1/4w		6099-1305
R736	Composition, 1 kΩ ±5% 1/4w		6099-2105
R737	Composition, 300 Ω ±5% 1/4w		6099-1305
R738	Composition, 300 Ω ±5% 1/4w		6099-1305
R739 thru R744	Composition, 2.2 kΩ ±5% 1/4w		6099-2225
R745	Composition, 270 Ω ±5% 1/4w		6099-1275
R746	Composition, 820 Ω ±5% 1/4w		6099-1825
R747	Composition, 820 Ω ±5% 1/4w		6099-1825
R748	Composition, 820 Ω ±5% 1/4w		6099-1825
R749 thru R756	Composition, 4.7 kΩ ±5% 1/4w		6099-2475
R757	Composition, 200 Ω ±5% 1/4w		6099-1205
R801	Composition, 24 Ω ±5% 1/4w		6100-0245
R802	Composition, 47 kΩ ±5% 1/2w		6100-3475
R803	Composition, 5.6 kΩ ±5% 1/2w		6100-2565
R804	Composition, 470 Ω ±5% 1w		6110-1475
R805	Potentiometer, composition, 5 kΩ ±10%; uses 5530-0400 gray knob	TRIGGER LEVEL	6045-1060
R806	Composition, 910 kΩ ±5% 1/2w		6100-4915
R807	Composition, 75 Ω ±5% 1w		6110-0755
R808	Composition, 510 kΩ ±5% 1/2w		6100-4515
R809	Composition, 1 kΩ ±5% 1/4w		6099-2105
R810	Composition, 10 kΩ ±5% 1/4w		6099-3105

	REF NO.	DESCRIPTION		PART NO.
	R811	Composition, 10 Ω ±5% 1/2w		6100-0105
	R812	Composition, 10 kΩ ±5% 1/4w		6099-3105
	R901 thru R950	Composition, 2.4 kΩ ±5% 1/4w		6099-2245
SWITCHES	S501	Toggle, dpst	POWER	7910-8353
	S502	Slide, dpst	TIME BASE	7910-0774
	S801	Rotary, 3-position, 2-section, non-shorting; uses 5530-0400 gray knob	MEASUREMENT	7890-3910
	S802	Toggle, spdt	INPUT COUPLING	7910-0792
	S803	Toggle, spdt	IMPEDANCE	7910-0792
	S804	Push-button, spdt, Microswitch	RESET	7870-1123
	S805	Rotary, 9-position, 1-section, non-shorting; uses 5530-0400 gray knob	DISPLAY TIME	7890-3920
	S806	Rotary, 4-position, 2-section, non-shorting; uses 5500-1700 gray knob	COUNTING TIME	7890-3930
	S807	Toggle, dpdt	COUNT/MULT INT	7910-1500
SOCKETS	SO101 thru SO701	18-contact, Methode No. CDG18S		4230-2699
	SO801	8-contact, Jones,No. S-308-AB	AUX	
	SO901	52-contact, Amphenol No. 220-698-01	COUNTING UNIT OUTPUT	4230-5000
TRANSFORMERS	T401	Pulse transformer		5000-6010
	T402	Pulse transformer		5000-6010
	T403	Pulse transformer		5000-6010
	T501	Power transformer		0485-4024
CRYSTAL	X501	Crystal, 200-kc, GT-cut		1153-0420



NOTES:
START:
1. END OF DISPLAY TIME SET ZERO "0" ARRIVES
2. 100 cps TRIGGERS COME THROUGH INVERTER

* DELAY PRODUCED BY THE CHARGING OF STRAY CAPACITANCES AT G_2 & G_3 THROUGH 10KΩ

(1) SET ZERO PULSE, BECAUSE OF ITS LONGER TIME DURATION OVERRIDES THE OUTPUT PULSE FROM INVERTER

(2) OUTPUT PULSE TRANSMITTED FROM A SCALE OF 1000 IS NEGATIVE GOING FOR RESETTING PURPOSES BEFORE POSITIVE GOING (NOTE INPUTS TO G_4 & A_2)

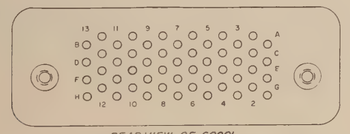
NOTE UNLESS SPECIFIED
ALL RESISTORS ARE REC-98F, 2.4KΩ ±5%

INDICATOR NUMERAL	BROWN FERRULES		RED FERRULES		BLUE FERRULES		YELLOW FERRULES		GREEN FERRULES	
	TO S0901	TO S0701	TO S0901	TO S0601	TO S0901	TO S0101	TO S0901	TO S0102	TO S0901	TO S0103
0	R901 A2	E5	R911 B2	E5	R921 D3	E5	R931 E10	E5	R941 G4	E5 (WH-BK)
1	R902 A4	F6	R912 B11	F6	R922 D5	F6	R932 E12	F6	R942 G6	F6 (WH-BR)
2	R903 A6	H7	R913 B13	H7	R923 D7	H7	R933 F1	H7	R943 G8	H7 (WH-RD)
3	R904 A8	J8	R914 C2	J8	R924 D9	J8	R934 F3	J8	R944 G10	J8 (WH-OR)
4	R905 A10	K9	R915 C4	K9	R925 D11	K9	R935 F5	K9	R945 G12	K9 (WH-YE)
5	R906 A12	L10	R916 C6	L10	R926 D13	L10	R936 F7	L10	R946 H1	L10 (WH-GN)
6	R907 B1	M11	R917 C8	M11	R927 E2	M11	R937 F9	M11	R947 H3	M11 (WH-BL)
7	R908 B3	N12	R918 C10	N12	R928 C4	N12	R938 F11	N12	R948 H5	N12 (WH-VT)
8	R909 B5	P13	R919 C12	P13	R929 E6	P13	R939 F13	P13	R949 H7	P13 (WH-GY)
9	R910 B7	R14	R920 D1	R14	R930 E8	R11	R940 G2	R14	R950 H9	R14 (WH)
	UNITS		TENS		HUNDREDS		THOUSANDS		TEN THOUSANDS	

H11 WH-GN-BR → A.T.507 (+20V)

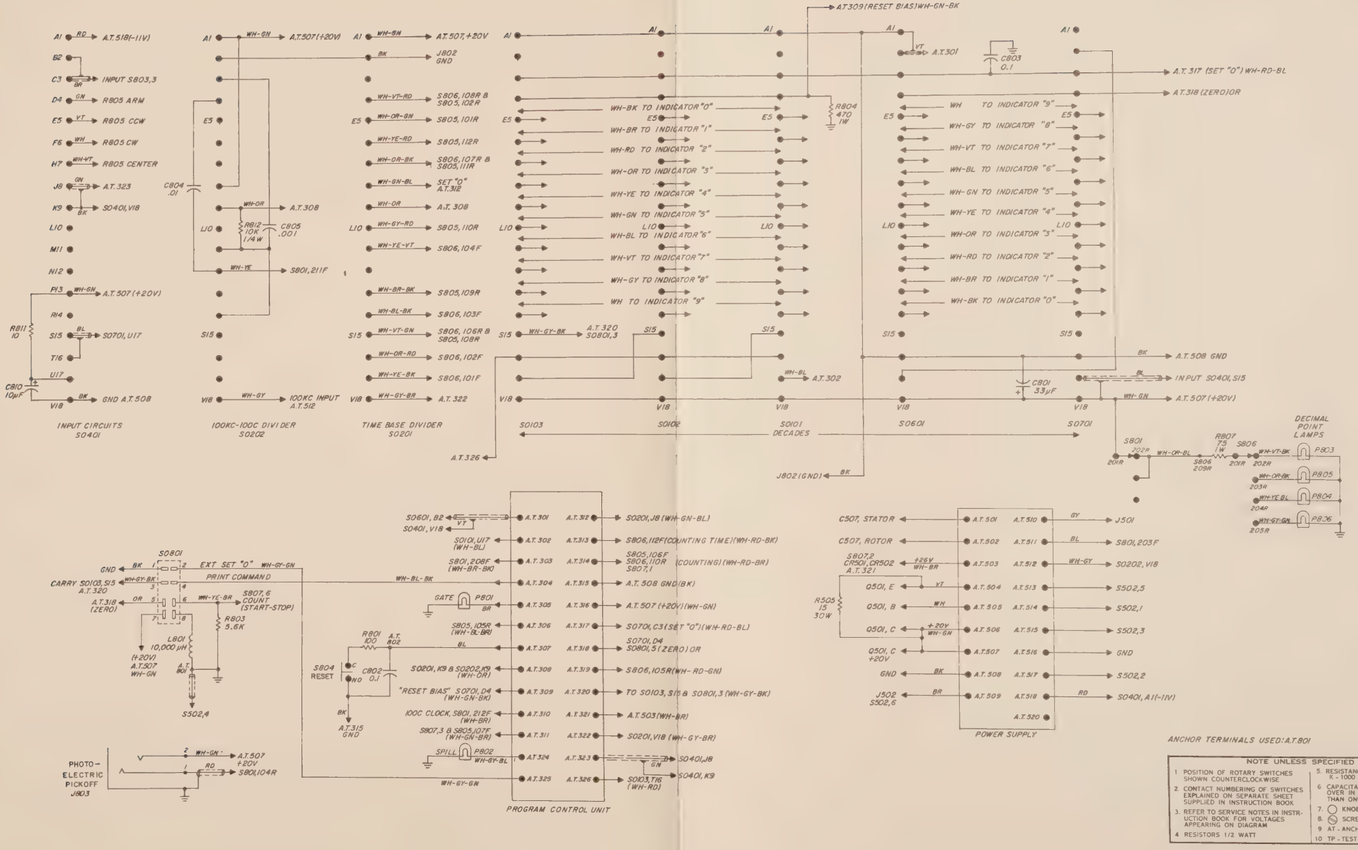
H13 → S0801,4 PRINT COMMAND

S0901 EXTERNAL ACCESSORY SOCKET



REAR VIEW OF S0901

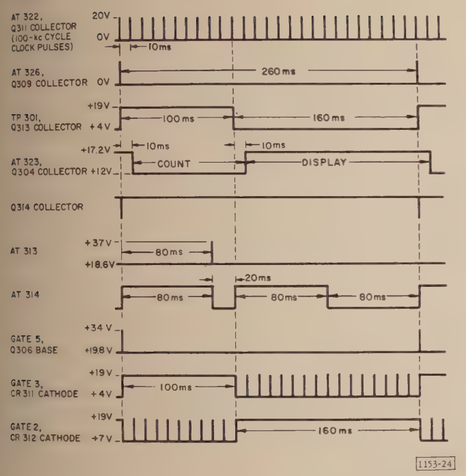
NOTE: FOR SCHEMATIC DIAGRAMS SEE 10-kc BCD COUNTING UNIT, PAGE 55; 1-kc BCD COUNTING UNIT, PAGE 57; 220-kc DECIMAL RING COUNTING UNIT, PAGE 59; AND 40-kc DECIMAL RING COUNTING UNIT, PAGE 61.



NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM
4. RESISTORS 1/2 WATT
5. RESISTANCE IN OHMS K = 1000 OHMS M = 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN MICROFARADS, LESS THAN ONE IN MICROFARADS
7. KNOB CONTROL
8. SCREWDRIVER CONTROL
9. AT - ANCHOR TERMINAL
10. TP - TEST POINT

TIMING



VOLTAGES

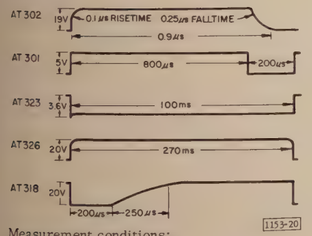
Transistor	DC Voltage to Ground Terminal e	b	c
Q301	+19.0	+18.5	+18.8
Q302	+19.0	+19.3	0
Q303	+17.1	+23.2	+12.0
Q304	+17.1	+16.7	+17.0
Q305	+19.0	+19.5	+ 2.7
Q306	+20.0	+19.8	+19.9
Q307	+19.2	+19.9	0
Q308	0	0	+20.7
Q309	0	+ 0.8	+ 0.5
Q310	+14.9	+15.5	+20.0
Q311	+19.3	+20.0	0
Q312	+19.3	+19.8	+ 6.5
Q313	+19.3	+19.0	+19.2
Q314	0	0	+20.7
Q315	+19.2	+20.5	0
Q316	+19.2	+20.0	0
Q317	+19.3	+19.0	+19.2
Q318	+19.2	+19.2	0

Measurement conditions:

TRIGGER LEVEL. . . . centered
MEASUREMENT. . . . . COUNT
COUNTING TIME. . . . MULT INT
COUNT/MULT INT. . . STOP

No input signal applied. Voltmeter impedance at least 20,000 ohms per volt. Push RESET button each time a voltmeter connection is made.

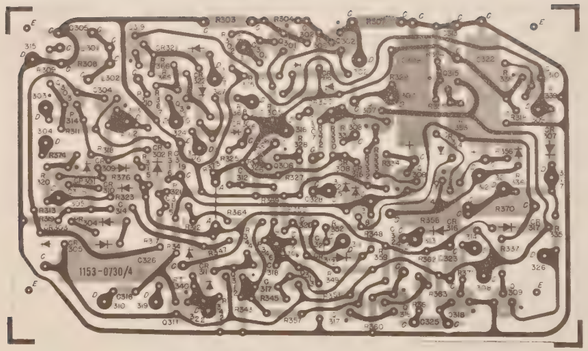
WAVEFORMS

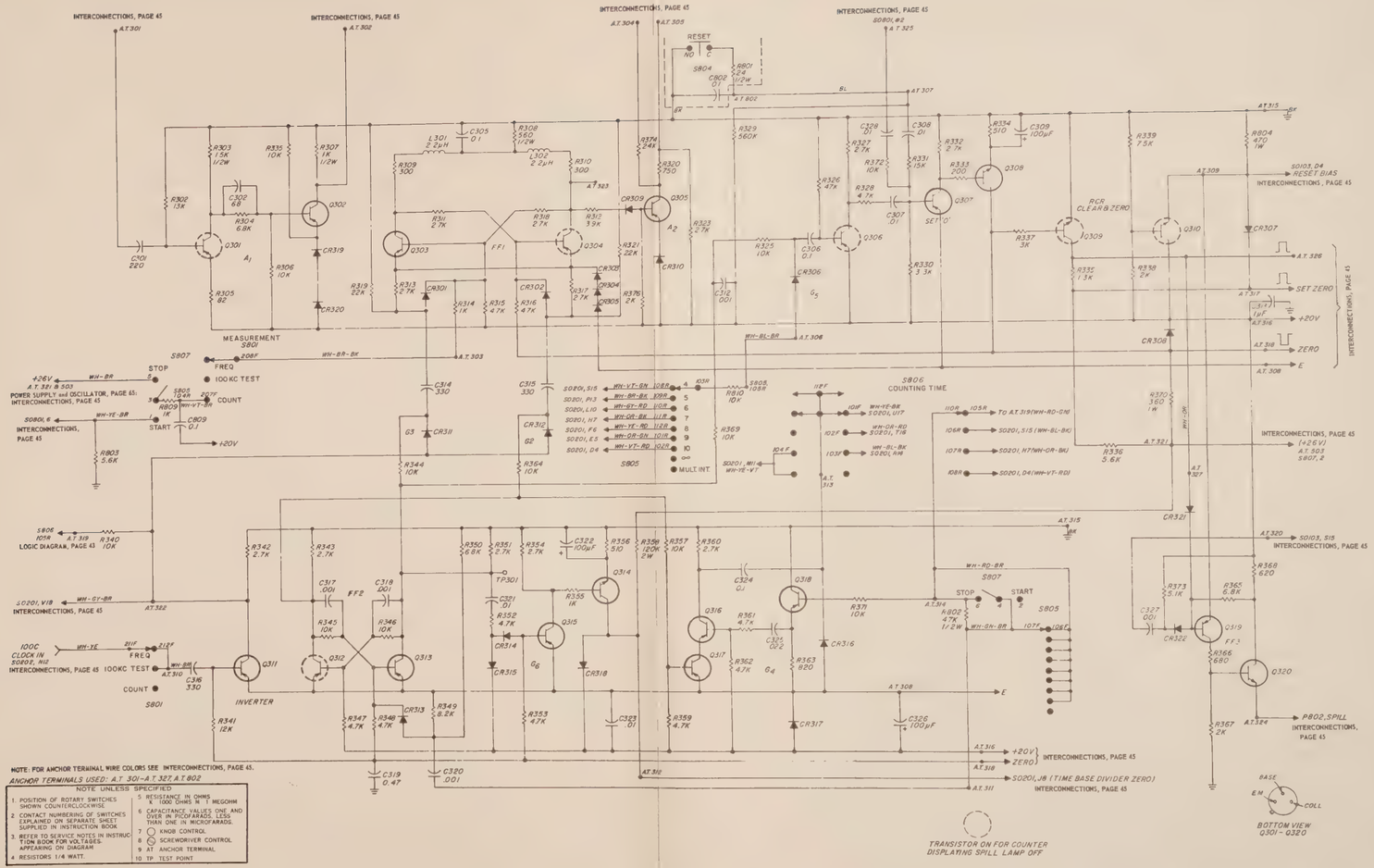


Measurement conditions:

MEASUREMENT. . . . .100 kc TEST
DISPLAY TIME. 4
COUNTING TIME. . . . 0.1 SEC

Trigger oscilloscope from zero-set pulse (AUX socket on rear panel, pin 5)




INTERCONNECTIONS, PAGE 45
A.T. 301
A.T. 302
A.T. 304
A.T. 305
A.T. 325
RESET
S804
S801, #2
S801, #1
S807
S805
S806
COUNTING TIME
MEASUREMENT
FREQ
100 KC TEST
COUNT
START
STOP
MULT INT
INVERTER
FF1
FF2
FF3
RCR CLEAR & ZERO
SET '0'
SET '1'
SET ZERO
ZERO
+20V
+26V
RESET BIAS
TRANSISTOR ON FOR COUNTER DISPLAYING SPILL LAMP OFF
BOTTOM VIEW Q301 - Q320
NOTE: FOR ANCHOR TERMINAL WIRE COLORS SEE INTERCONNECTIONS, PAGE 45.
ANCHOR TERMINALS USED: A.T. 301-A.T. 327, A.T. 802
NOTE UNLESS SPECIFIED
1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM
4. RESISTORS 1/4 WATT
5. RESISTANCE IN OHMS K = 1000 OHMS M = 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS.
7. KNOB CONTROL
8. SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT

VOLTAGES

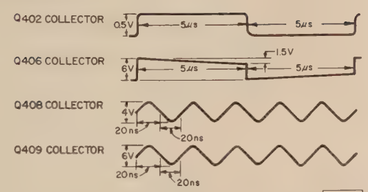
Transistor	DC Voltage to Ground Terminal e	b	c
Q401	+ 9.7	+10.4	+14.8
Q402	+ 9.7	+10.4	+15.0
Q403A	- .68	- 0.06	+10.4
Q403B	- .68	- 0.06	+10.4
Q405	+15.5	+15.0	+ 8.5
Q406	+ 3.4	+ 3.6	+ 2.0
Q407	+ 3.4	+ 3.1	0
Q408	+16.5	+16.5	+ 9.5
Q409	+16.5	+16.8	+ 9.5
Q410	+16.5	+17.0	+16.5

Measurement conditions:

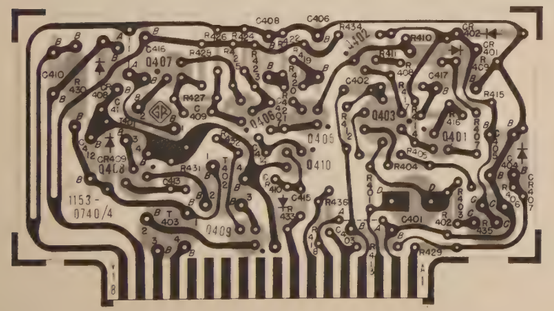
TRIGGER LEVEL. . . . centered
MEASUREMENT. . . . COUNT

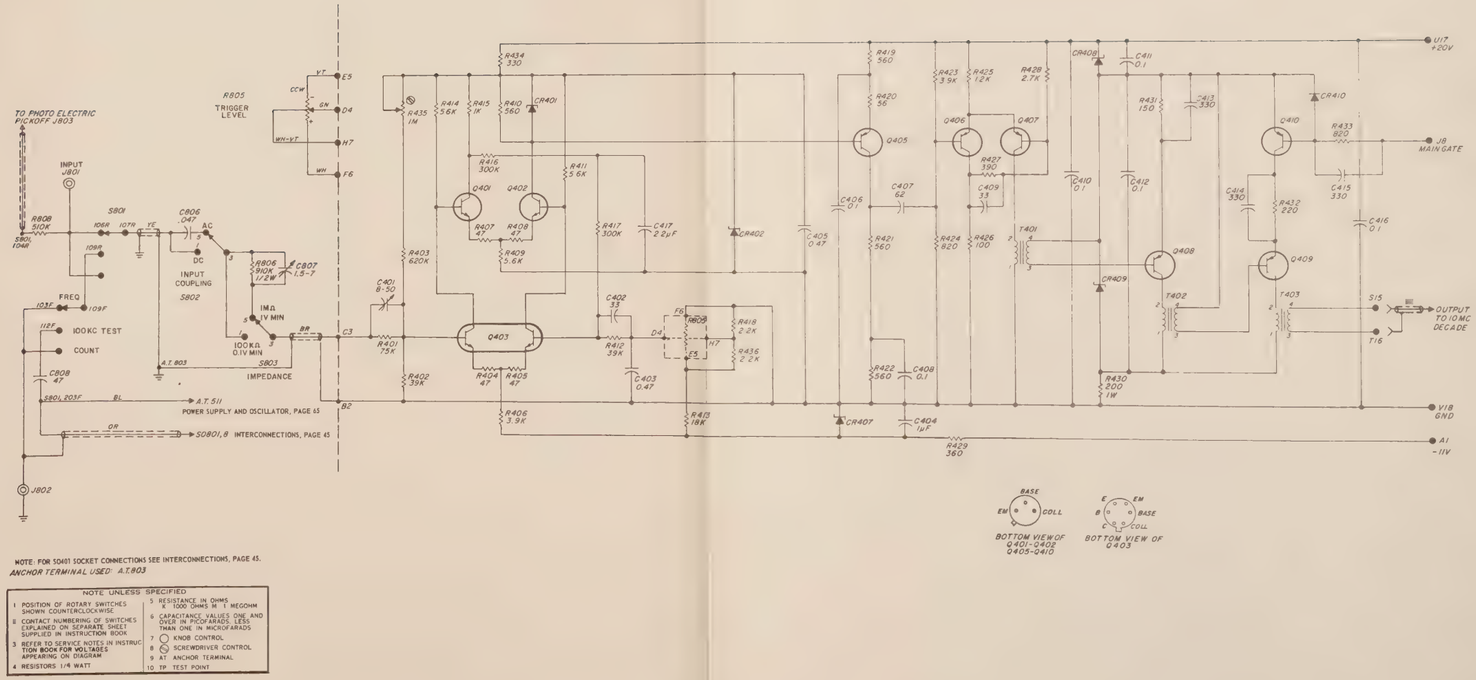
No input signal applied

WAVEFORMS



Measurement conditions:
TRIGGER LEVEL. . . . centered
INPUT COUPLING. . . . AC
IMPEDANCE. . . . . 100 kΩ
MEASUREMENT. . . . .100 kc TEST





NOTE: FOR S0401 SOCKET CONNECTIONS SEE INTERCONNECTIONS, PAGE 45.
ANCHOR TERMINAL USED: A.T.803

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/4 WATT
5. RESISTANCE IN OHMS K 1000 OHMS M 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS
7. KNOB CONTROL
8. SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT

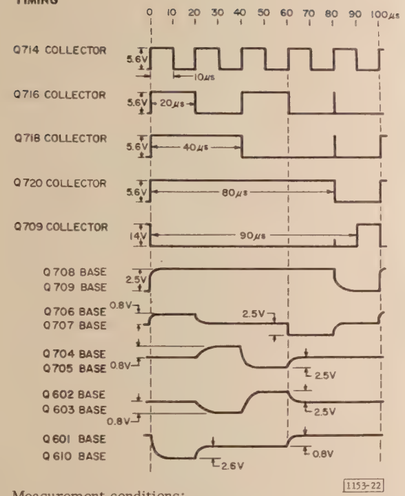
VOLTAGES

Transistor	DC Voltage to Ground Terminal e	b	c
Q701	+13.0	+13.0	0
Q702	+13.5	+15.5	0
Q703	+13.0	+15.5	0
Q704	+13.5	+15.5	0
Q705	+13.0	+15.5	0
Q706	±13.5	+16.0	0
Q707	+13.0	+16.0	0
Q708	+13.5	+15.4	0
Q709	+13.0	+15.4	0
Q710	+13.5	+13.0	+13.4
Q711	+13.6	+13.1	+13.5
Q712	+13.6	+15.6	+13.0
Q713	+17.0	+17.6	+11.5
Q714	+17.0	+16.5	+16.9
Q715	+17.0	+17.6	+11.5
Q716	+17.0	+16.5	+16.9
Q717	+17.0	+17.6	+11.5
Q718	+17.0	+16.5	+16.9
Q719	+17.0	+17.6	+11.5
Q720	+17.0	+16.5	+16.9

Measurement conditions:

MEASUREMENT. . . . . COUNT
DISPLAY TIME. 10
COUNT/MULT INT. . . STOP

TIMING



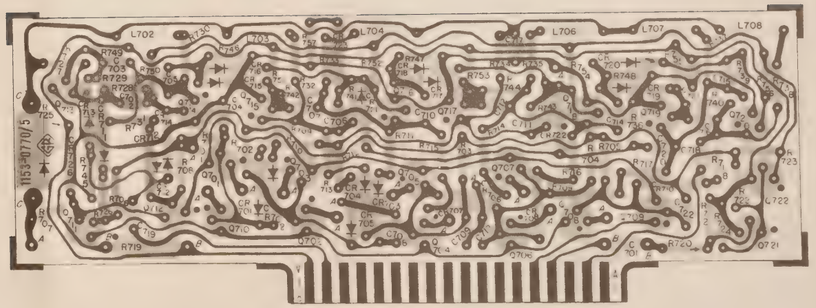
1153-22

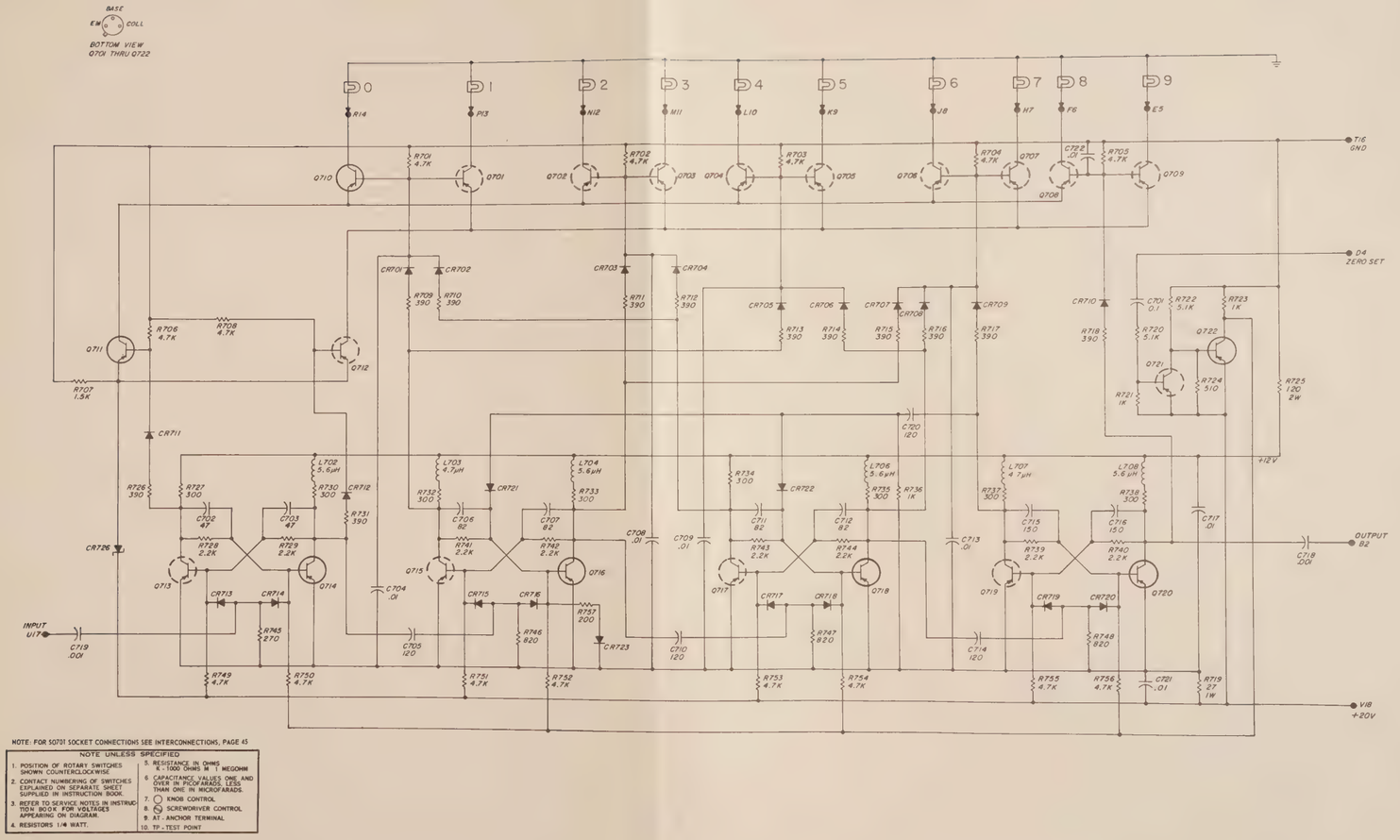
Measurement conditions:

TRIGGER LEVEL. . . . centered
INPUT COUPLING. . . . AC
IMPEDANCE. . . . . .100 kΩ
MEASUREMENT. . . . 100 kc TEST
DISPLAY TIME. 4
COUNTING TIME. . . . 10 SEC

DECADE CODE

DECIMAL	BINARY FF1	FF2	FF3	FF4
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	1	1	1
9	1	1	1	1
0	0	0	0	0





NOTE: FOR 50701 SOCKET CONNECTIONS SEE INTERCONNECTIONS, PAGE 45

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/4 WATT.
5. RESISTANCE IN OHMS K = 1000 OHMS M = 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS.
7. ◯ KNOB CONTROL
8. ⊖ SCREWDRIVER CONTROL
9. AT - ANCHOR TERMINAL
10. TP - TEST POINT

1-Mc/s COUNTER

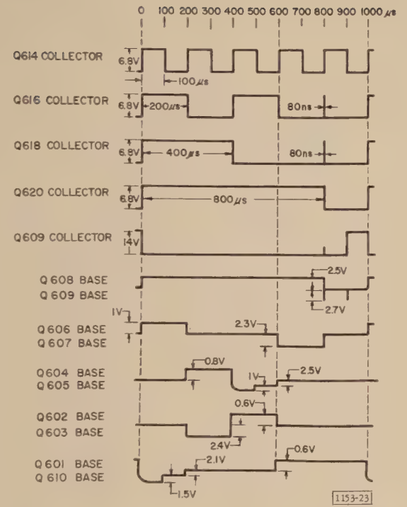
VOLTAGES

Transistor	DC Voltage to Ground Terminal e	b	c
Q601	+13.1	+13.1	0
Q602	+13.6	+15.0	0
Q603	+13.1	+15.0	0
Q604	+13.6	+14.9	0
Q605	+13.1	+14.9	0
Q606	+13.6	+15.6	0
Q607	+13.1	+15.6	0
Q608	+13.6	+15.0	0
Q609	+13.1	+15.0	0
Q610	+13.6	+13.1	+13.4
Q611	+13.8	+13.5	+13.6
Q612	+13.8	+15.0	+13.1
Q613	+16.7	+17.8	+10.2
Q614	+16.7	+16.4	+16.6
Q615	+16.7	+17.8	+10.2
Q616	+16.7	+16.4	+16.6
Q617	+16.7	+17.8	+10.2
Q618	+16.7	+16.4	+16.6
Q619	+16.7	+17.8	+10.2
Q620	+16.7	+16.4	+16.6

Measurement conditions:

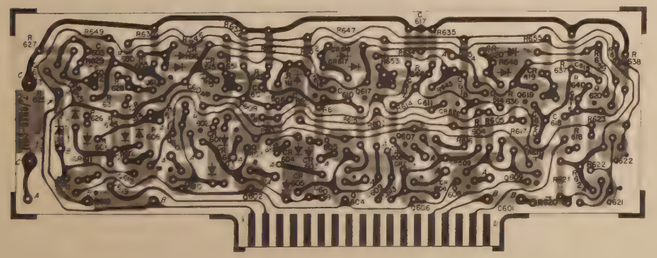
MEASUREMENT. . . . . COUNT
DISPLAY TIME. 10
COUNT/MULT INT. . . STOP

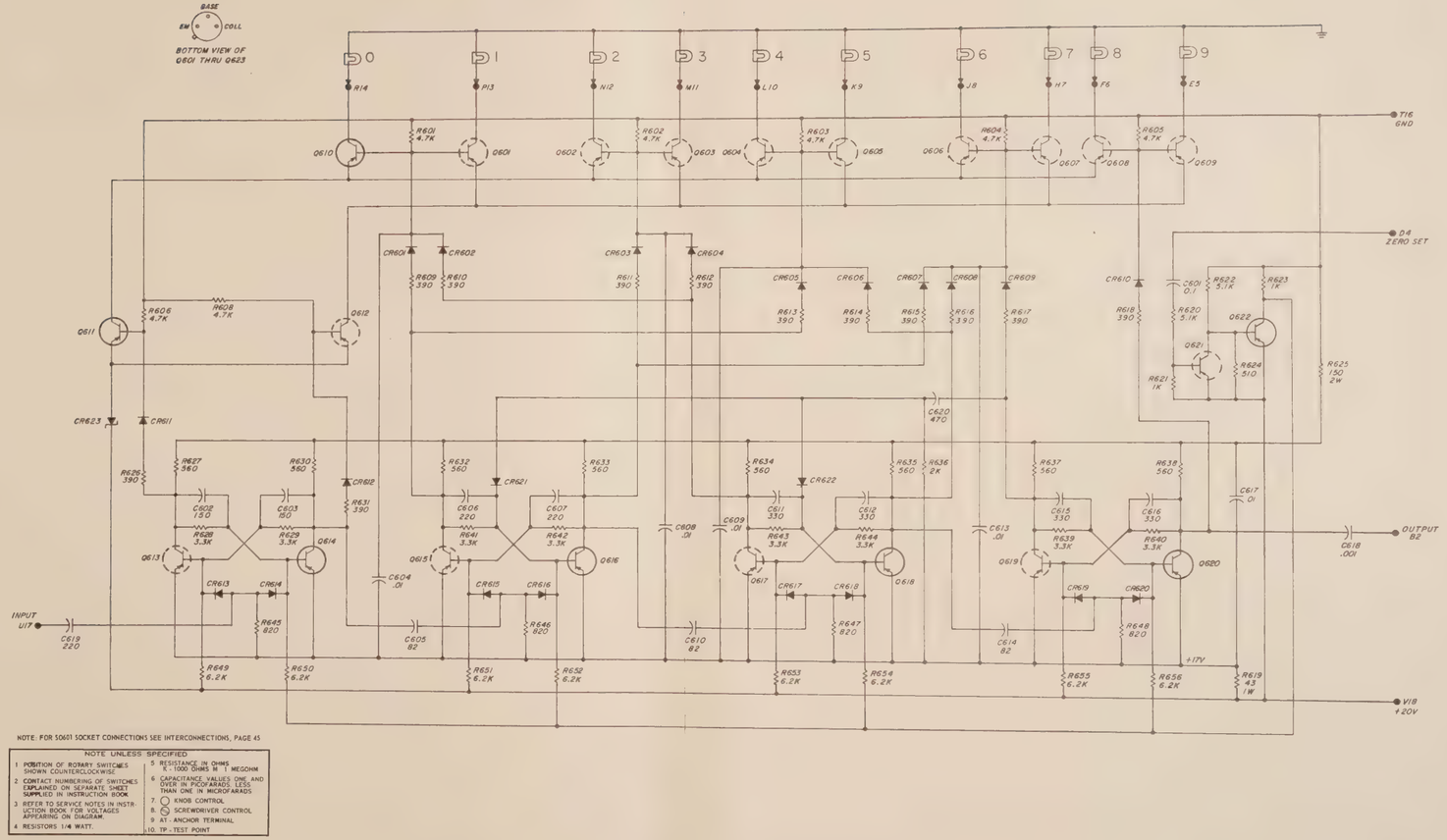
TIMING



Measurement conditions:

TRIGGER LEVEL . . . centered
INPUT COUPLING . . . . AC
IMPEDANCE. . . . . 100 kΩ
MEASUREMENT. . . . .100 kc TEST
DISPLAY TIME. 4
COUNTING TIME. . . . 10 SEC





NOTE: FOR S0601 SOCKET CONNECTIONS SEE INTERCONNECTIONS, PAGE 45

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/4 WATT.
5. RESISTANCE IN OHMS K = 1000 OHMS M = MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS
7. ◯ KNOB CONTROL
8. ⊖ SCREWDRIVER CONTROL
9. AT - ANCHOR TERMINAL
10. TP - TEST POINT

VOLTAGES

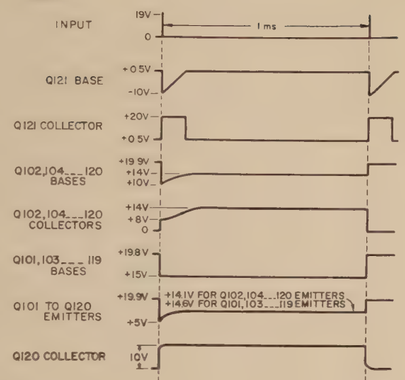
Transistor	DC Voltage to Ground Terminal e	b	c
Q101	+14.6	+15.0	+13.7
Q102	+14.0	+13.6	+13.7
Q103	+19.6	+19.4	+19.5
Q104	+19.6	+19.5	0
Q105	+19.6	+19.4	+19.5
Q106	+19.6	+19.5	0
Q107	+19.6	+19.4	+19.5
Q108	+19.6	+19.5	0
Q109	+19.6	+19.4	+19.5
Q110	+19.6	+19.5	0
Q111	+19.6	+19.4	+19.5
Q112	+19.6	+19.5	0
Q113	+19.6	+19.4	+19.5
Q114	+19.6	+19.5	0
Q115	+19.6	+19.4	+19.5
Q116	+19.6	+19.5	0
Q117	+19.6	+19.4	+19.5
Q118	+19.6	+19.5	0
Q119	+19.6	+19.4	+19.5
Q120	+19.6	+19.5	+ 3
Q121	+ 1.1	+ 1.95	+ 1.2

Measurement conditions:

MEASUREMENT. . . . . COUNT
COUNT/MULT INT. . . STOP

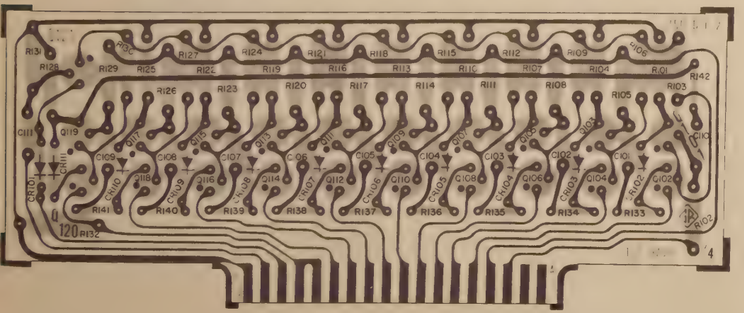
No input signal applied. RESET button pushed to give a display of 00000.

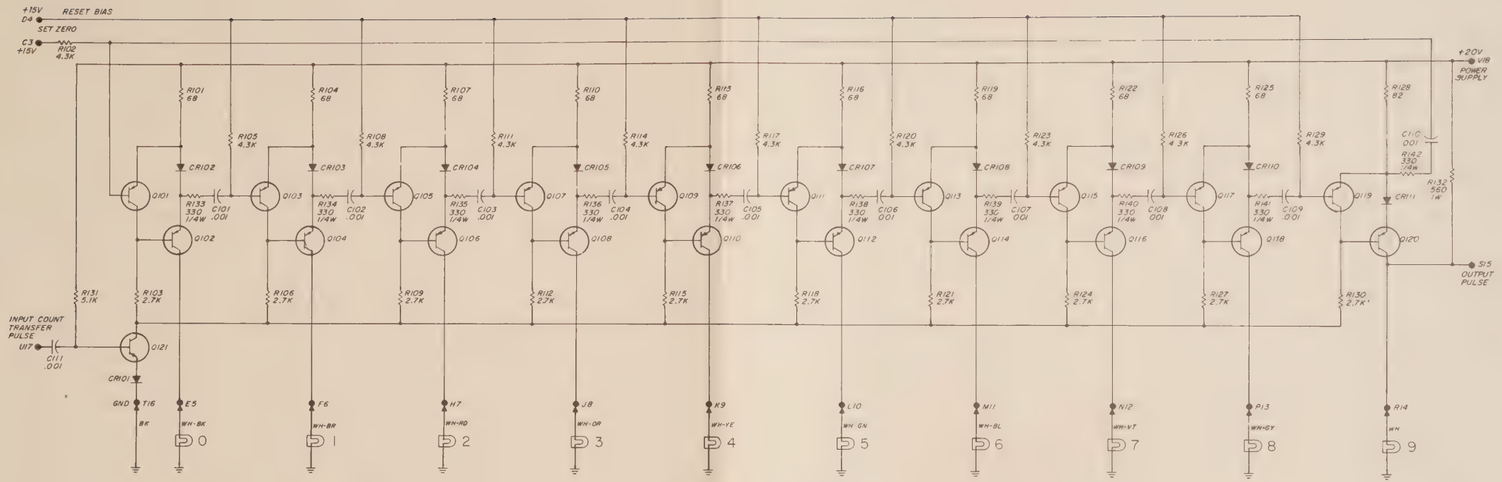
TIMING



Measurement conditions:

TRIGGER LEVEL. . . . centered
INPUT COUPLING. . . . AC
IMPEDANCE. . . . . 100 kΩ
MEASUREMENT. . . . 100 kc TEST
DISPLAY TIME. 4
COUNTING TIME. . . . 10 SEC





LAMPS 0 THRU 9 PART OF INDICATOR IND-0300

BOTTOM VIEW Q101 THRU Q121

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/2 WATT.
5. RESISTANCE IN OHMS K - 1000 OHMS M - 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS
7. KNOB CONTROL
8. SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT

SOCKET PIN CONNECTIONS: SO101

A1	
B2	
C3	SET ZERO PULSE, POS. PULSE FROM 15 VOLTS (WH-BR-BK)
D4	RESET PULSE, NEG. PULSE FROM 15 VOLTS (WH-GN-BL)
E5	TO 0 LAMP (WH-BK)
F6	TO 1 LAMP (WH-BR)
H7	TO 2 LAMP (WH-RD)
J8	TO 3 LAMP (WH-OR)
K9	TO 4 LAMP (WH-YE)
L10	TO 5 LAMP (WH-GN)
M11	TO 6 LAMP (WH-BL)
N12	TO 7 LAMP (WH-VT)
P13	TO 8 LAMP (WH-GY)
R14	TO 9 LAMP (WH)
S15	OUTPUT PULSE
T16	GND (BK)
U17	INPUT COUNT TRANSFER PULSE (WH-RD-BK)
V18	+20 VOLT SUPPLY (WH-GN-BR)

40-kc/s COUNTER

VOLTAGES

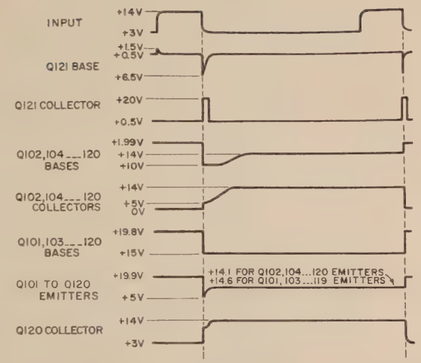
Transistor	DC Voltage to Ground Terminal e	b	c
Q101	+14.5	+15.0	+13.5
Q102	+13.9	+13.5	+13.7
Q103	+19.6	+19.4	+19.5
Q104	+19.6	+19.5	0
Q105	+19.6	+19.4	+19.5
Q106	+19.6	+19.5	0
Q107	+19.6	+19.4	+19.5
Q108	+19.6	+19.5	0
Q109	+19.6	+19.4	+19.5
Q110	+19.6	+19.5	0
Q111	+19.6	+19.4	+19.5
Q112	+19.6	+19.5	0
Q113	+19.6	+19.4	+19.5
Q114	+19.6	+19.5	0
Q115	+19.6	+19.4	+19.5
Q116	+19.6	+19.5	0
Q117	+19.6	+19.4	+19.5
Q118	+19.6	+19.5	0
Q119	+19.6	+19.4	+19.5
Q120	+19.6	+19.5	+ 3.0
Q121	+ .45	+ .85	+ .65

Measurement conditions:

MEASUREMENT. . . . .COUNT
COUNT/MULT INT. . .STOP

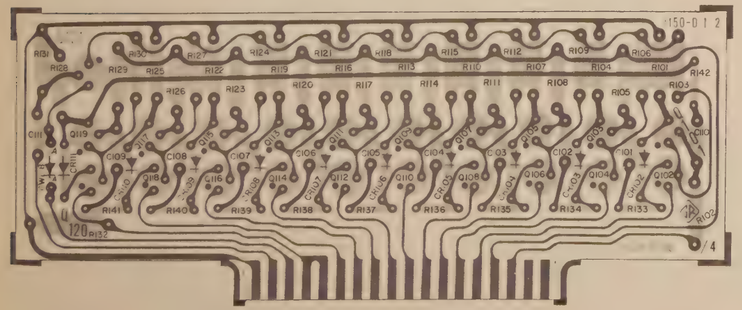
No input signal applied, RESET button pushed to give a display of 00000.

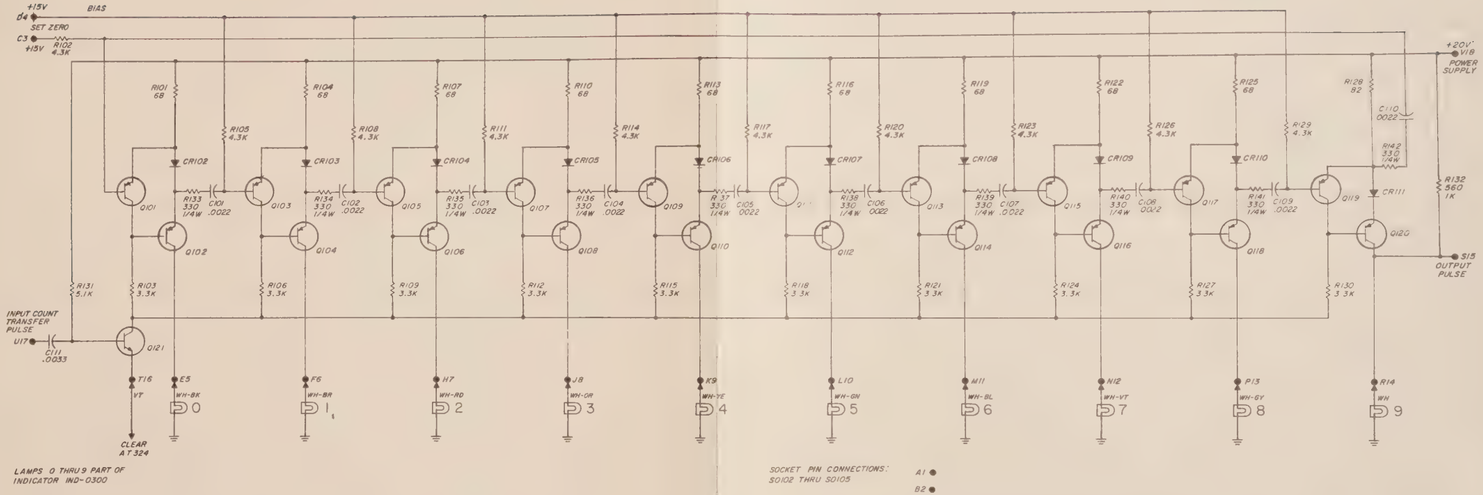
TIMING



Measurement conditions:

TRIGGER LEVEL. . . . centered
INPUT COUPLING. . . . AC
IMPEDANCE. . . . . 100 kΩ
MEASUREMENT. . . . .100 kc TEST
DISPLAY TIME. 4
COUNTING TIME. . . . 10 SEC





BOTTOM VIEW Q101 THRU Q121

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM
4. RESISTORS 1/2 WATT
5. RESISTANCE IN OHMS K = 1000 OHMS M = 1 MEGOHM
6. CAPACITANCE VALUES ONE AND TWO ARE MICROFARADS LESS THAN ONE IN MICROFARADS
7. KNOB CONTROL
8. SCREWDRIVER CONTROL
9. AT - ANCHOR TERMINAL
10. TP - TEST POINT

SOCKET PIN CONNECTIONS: S0102 THRU S0105

- A1
- B2
- C3 — SET ZERO PULSE, POS. PULSE FROM 15 VOLTS (WH-BR-BK)
- D4 — RESET PULSE, NEG. PULSE FROM 15 VOLTS (WH-GN-BL)
- E5 — TO 0 LAMP (WH-BK)
- F6 — TO 1 LAMP (WH-BR)
- H7 — TO 2 LAMP (WH-RD)
- J8 — TO 3 LAMP (WH-OR)
- K9 — TO 4 LAMP (WH-YE)
- L10 — TO 5 LAMP (WH-GN)
- M11 — TO 6 LAMP (WH-BL)
- N12 — TO 7 LAMP (WH-VT)
- P13 — TO 8 LAMP (WH-GY)
- R14 — TO 9 LAMP (WH)
- S15 — OUTPUT PULSE
- T16 — AT 324 (VT)
- U17 — INPUT COUNT TRANSFER PULSE (WH-RO-BK)
- V18 — +20 VOLT SUPPLY (WH-GN-BR)

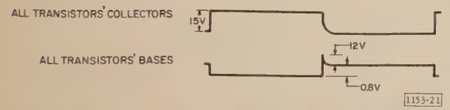
TIME BASE DIVIDER

WHEN PLUGGED INTO SO201	DC Voltage to Ground Terminal			WHEN PLUGGED INTO SO202	DC Voltage to Ground Terminal		
Transistor	e	b	*c	Transistor	e	b	*c
Q201	+19.4	+19.0	+ 5.5	Q201	+19.2	+19.0	+19.2
Q202	+19.4	+19.0	+19.2	Q202	+19.2	+19.9	+ 5.5
Q203	+19.4	+19.0	+ 5.5	Q203	+19.2	+19.0	+19.2
Q204	+19.4	+19.0	+19.2	Q204	+19.2	+19.9	+ 5.5
Q205	+19.4	+19.0	+ 5.5	Q205	+19.2	+19.0	+19.2
Q206	+19.4	+19.0	+19.2	Q206	+19.2	+19.9	+ 5.5
Q207	+19.4	+19.0	+ 5.5	Q207	+19.2	+19.0	+19.2
Q208	+19.4	+19.0	+19.2	Q208	+19.2	+19.9	+ 5.5
Q209	+19.4	+19.0	+ 5.5	Q209	+19.2	+19.0	+19.2
Q210	+19.4	+19.0	+19.2	Q210	+19.2	+19.9	+ 5.5
Q211	+19.4	+19.0	+ 5.5	Q211	+19.2	+19.0	+19.2
Q212	+19.4	+19.0	+19.2	Q212	+19.2	+19.9	+ 5.5
Q213	+19.4	+19.0	+ 5.5	Q213	+19.2	+19.0	+19.2
Q214	+19.4	+19.0	+19.2	Q214	+19.2	+19.9	+ 5.5
Q215	+19.4	+19.0	+ 5.5	Q215	+19.2	+19.0	+19.2
Q216	+19.4	+19.0	+19.2	Q216	+19.2	+19.9	+ 5.5
Q217	+19.4	+19.0	+ 5.5	Q217	+19.2	+19.0	+19.2
Q218	+19.4	+19.0	+19.2	Q218	+19.2	+19.9	+ 5.5
Q219	+19.4	+19.0	+ 5.5	Q219	+19.2	+19.0	+19.2
Q220	+19.4	+19.0	+19.2	Q220	+19.2	+19.9	+ 5.5

Measurement conditions:

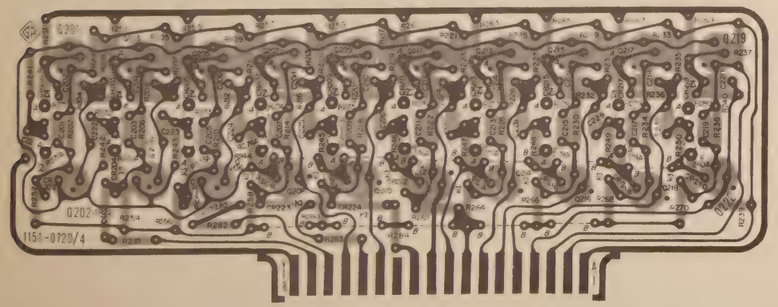
TIME BASE (rear). . .EXT

*Collector voltages may be reversed depending on how far the divider has counted before the TIME BASE switch was set to EXT. For instance, the voltages may be as shown through Q208 but the odd transistor may be 19.2 V and the even transistor may be 5.5 V from Q209 through Q220



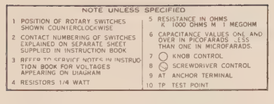
Measurement conditions:

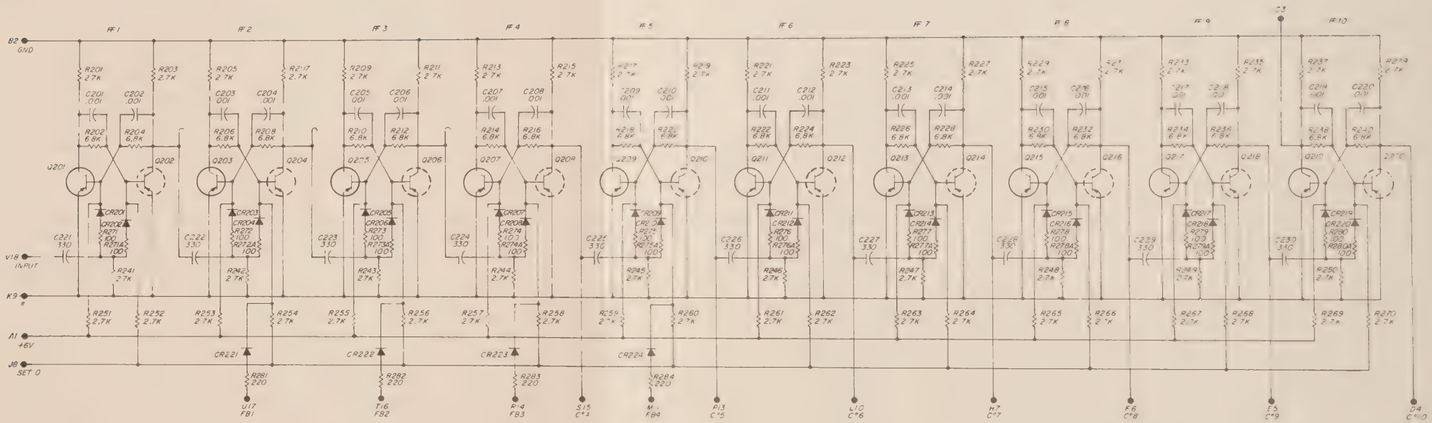
MEASUREMENT. . . . FREQUENCY
DISPLAY TIME. 4
COUNTING TIME . . . .10 SEC



NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM
4. RESISTORS 1/4 WATT
5. RESISTANCE IN OHMS K - 1000 OHMS M - 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN MICROFARADS. LESS THAN ONE IN MICROFARADS.
7. KNOB CONTROL
8. SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT

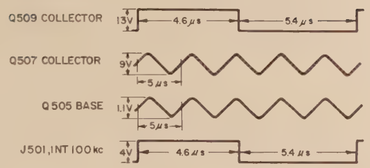


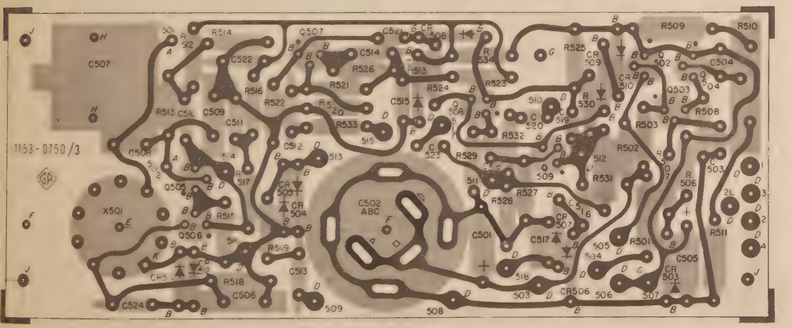


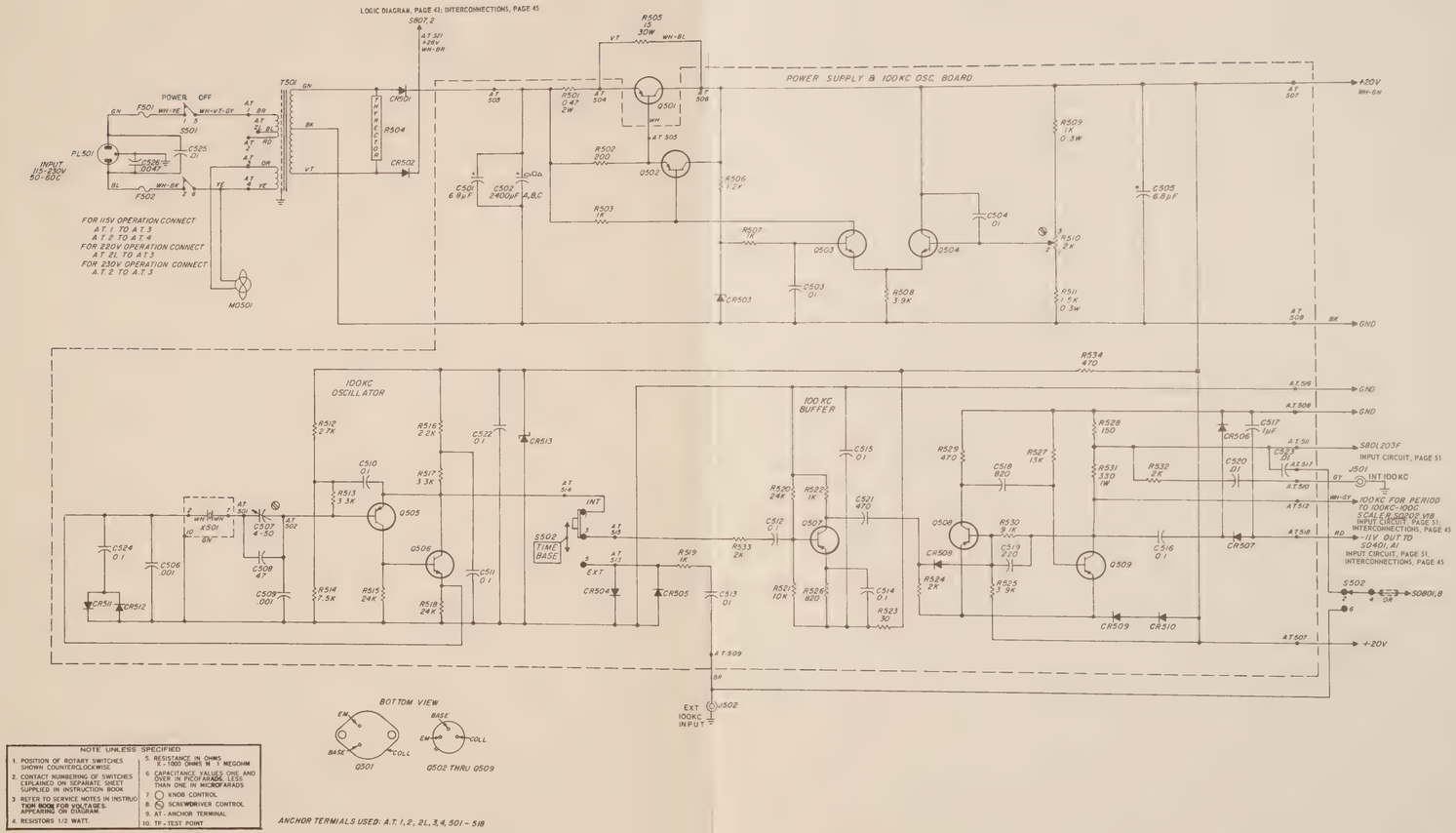
VOLTAGES

Transistor	DC Voltage to Ground Terminal e	b	c
Q501	+32.2	+32.0	+20.0
Q502	+32.0	+31.5	+20.0
Q503	+11.5	+11.8	+31.0
Q504	+20.0	+11.7	+20.0
Q505	+11.1	+10.9	+ 7.5
Q506	+ 8.7	+ 7.5	+11.1
Q507	+10.6	+10.9	+ 4.7
Q508	+18.8	+18.8	+11.0
Q509	+18.8	+21.8	+12.0
AT518		-10.0	

WAVEFORMS

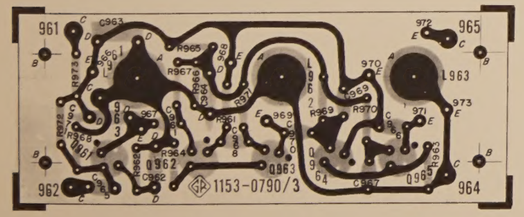






PARTS LIST

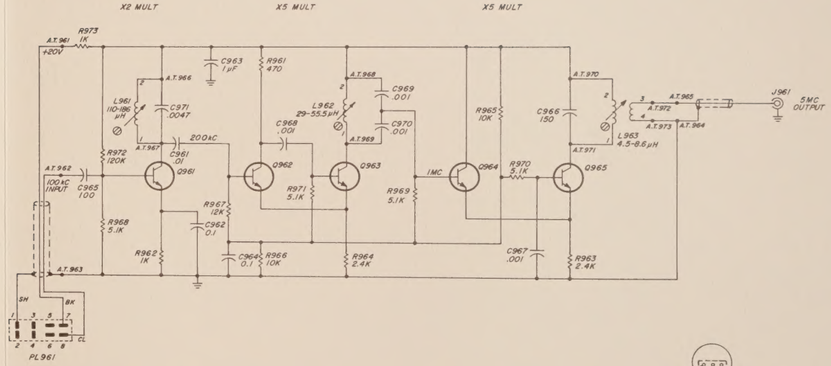
REF NO.	DESCRIPTION	PART NO.
Capacitors		
C961	Ceramic, 0.01 µF +80-20% 50V	4401-3100
C962	Ceramic, 0.1 µF +80-20% 50V	4403-4100
C963	Ceramic, 1 µF ±20% 25V	4400-2070
C964	Ceramic, 0.1 µF +80-20% 50V	4403-4100
C965	Ceramic, 100 pF ±5% 500V	4404-1105
C966	Ceramic, 150 pF ±5% 500V	4404-1155
C967	Ceramic, 0.001 µF +80-20% 500V	4404-2109
C968	Ceramic, 0.001 µF ±5% 500V	4405-2105
C969	Ceramic, 0.001 µF ±5% 500V	4405-2105
C970	Ceramic, 0.001 µF ±5% 500V	4405-2105
C971	Ceramic, 0.0047 µF ±5% 500V	4407-2475
Inductors		
L961	Variable, 110 to 186 µH	4290-4265
L962	Variable, 29 to 55.5 µH	4290-4250
L963	Variable, 4.5 to 8.6 µH	4290-4050
Plug		
PL961	8 contact, Jones No. 261-31-08-030	4220-5000
Transistors		
Q961 thru Q965	Type 2N2714	8210-1047
Resistors		
R961	Composition, 470 Ω ±5% 1/4w	6099-1475
R962	Composition, 1 kΩ ±5% 1/4w	6099-2105
R963	Composition, 2.4 kΩ ±5% 1/4w	6099-2245
R964	Composition, 2.4 kΩ ±5% 1/4w	6099-2245
R965	Composition, 10 kΩ ±5% 1/4w	6099-3105
R966	Composition, 10 kΩ ±5% 1/4w	6099-3105
R967	Composition, 12 kΩ ±5% 1/4w	6099-3125
R968	Composition, 5.1 kΩ ±5% 1/4w	6099-2515
R969	Composition, 5.1 kΩ ±5% 1/4w	6099-2515
R970	Composition, 5.1 kΩ ±5% 1/4w	6099-2515
R971	Composition, 5.1 kΩ ±5% 1/4w	6099-2515
R972	Composition, 120 kΩ ±5% 1/4w	6099-4125
R973	Composition, 1 kΩ ±5% 1/4w	6099-2105



NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/4 WATT.
5. RESISTANCE IN OHMS K - 1000 OHMS M - 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN MICROFARADS LESS THAN ONE IN MICROFARADS.
7. KNOB CONTROL
8. SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT

ANCHOR TERMINALS USED: A.T. 961 - A.T. 973



GENERAL RADIO COMPANY

WEST CONCORD, MASSACHUSETTS 01781

617 369-4400 617 646-7400

50821

SALES ENGINEERING OFFICES

NEW ENGLAND*
22 Baker Avenue
West Concord, Massachusetts 01781
Telephone 617 646-0550

METROPOLITAN NEW YORK*
Broad Avenue at Linden
Ridgefield, New Jersey 07657
Telephone N.Y. 212 964-2722
N.J. 201 943-3140

SYRACUSE
Pickard Building
East Molloy Road
Syracuse, New York 13211
Telephone 315 454-9323

PHILADELPHIA
Fort Washington Industrial Park
Fort Washington, Pennsylvania 19034
Telephone 215 646-8030

WASHINGTON* and BALTIMORE
11420 Rockville Pike
Rockville, Maryland 20852
Telephone 301 946-1600

ORLANDO
113 East Colonial Drive
Orlando, Florida 32801
Telephone 305 425-4671

CHICAGO*
6605 West North Avenue
Oak Park, Illinois 60302
Telephone 312 848-9400

CLEVELAND
5579 Pearl Road
Cleveland, Ohio 44129
Telephone 216 886-0150

LOS ANGELES*
1000 North Seward Street
Los Angeles, California 90038
Telephone 213 469-6201

SAN FRANCISCO
1186 Los Altos Avenue
Los Altos, California 94022
Telephone 415 948-8233

DALLAS*
2600 Stemmons Freeway, Suite 210
Dallas, Texas 75207
Telephone 214 637-2240

TORONTO*
99 Floral Parkway
Toronto 15, Ontario, Canada
Telephone 416 247-2171

MONTREAL
1255 Laird Boulevard
Town of Mount Royal, Quebec, Canada
Telephone 514 737-3673

www.manualsplus.com

1022537

* Repair services are available at these

General Radio Con *...rich, Switzerland*
General Radio Company (U *Buckinghamshire, England*
Representati *Countries*

Printed in USA